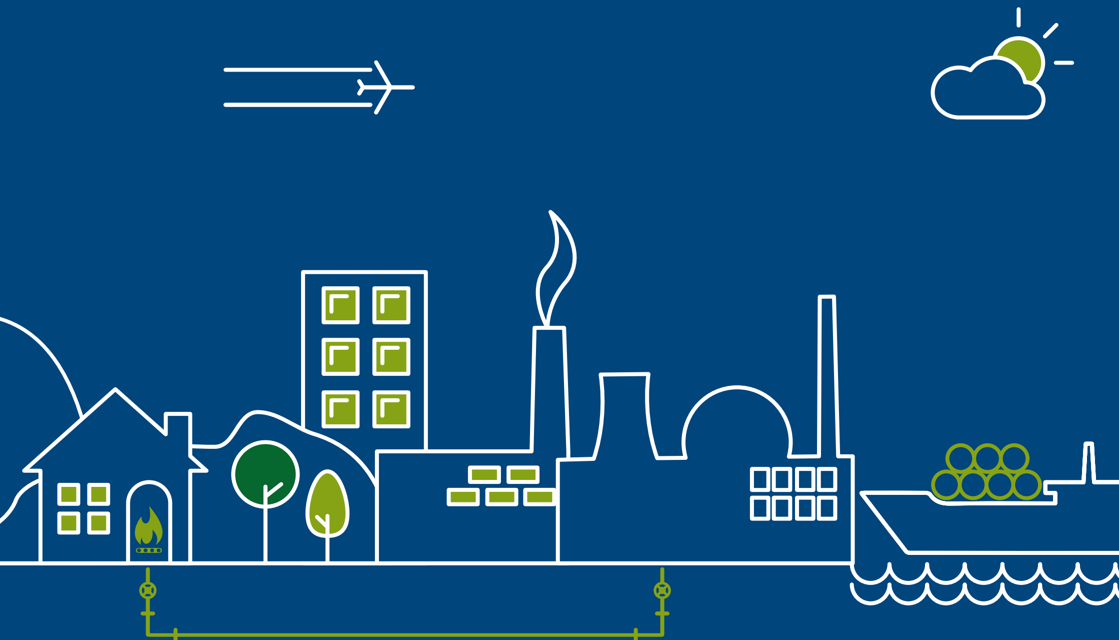
nationalgrid

Gas Future Operability Planning 2016

GB gas transmission



NOVEMBER 2016

How to use this document

To help you find the information you need quickly and easily we have published the *GFOP* as an interactive document.

Home
This will take you to the contents page. You can click on the titles to navigate to a section.

Arrows
Click on the arrows to move backwards or forwards a page.

Previous view
Click on the icon to go to the previous page viewed.

A to Z
You will find a link to the glossary on each page.

Hyperlinks
Hyperlinks are highlighted in bold throughout the report. You can click on them to access further information.

We are in the midst of an energy revolution. The economic landscape, developments in technology and consumer behaviour are changing at an unprecedented rate, creating more opportunities than ever for our industry.

Our *Gas Future Operability Planning (GFOP) publication*, along with our other System Operator publications, aims to encourage and inform debate, leading to changes that ensure a secure, sustainable and affordable energy future.

This is a first draft to demonstrate what this document could look like. We will use this as a building block to develop a more collaborative publication going forward. We want your views, knowledge and insight to shape future editions of this publication and to help us to better understand the future of energy impact on gas transmission. We look forward to engaging with you over the next year.

The current and future direction of energy policy and the shape, size and mix of the energy network in the UK is increasingly uncertain. Therefore we must consider the different and changing roles gas can play in both the short and long term to understand how our role might change; how the use of our asset base may evolve to meet changing customer needs and how market developments may impact the commercial regime.

There are some important choices to make about our priorities for investment and focus for innovation in order to provide long-term value for UK gas consumers and to ensure we continue to meet your needs. We must focus on the energy system as a whole rather than on its component parts to develop robust and adaptable solutions for the future.

I hope that you find this document, along with our other System Operator publications, useful as a catalyst for wider debate. For more information about all our publications, please see section 1.2.

Please share your views with us by getting in touch:
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Andy Malins
Head of Network Capability and Operations, Gas

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Executive summary

1.1 Executive summary

The *Gas Future Operability Planning (GFOP)* publication describes how your changing requirements may affect the future capability of the National Transmission System (NTS) out to 2050 and the challenges that these may pose to NTS operation and our processes. The *GFOP* will change the way we respond to you and other market signals, leading to modifications in our decision making and operational processes to ensure we continue to maintain a resilient, safe and secure NTS now and into the future.

This is a first draft of this document for your review and comment. Our aim is for future editions of this document to be more collaborative so all interested parties can highlight changes which will require us to quantify the effect on the future NTS capability and operability. We are keen to hear your views so this document can evolve and focus on what you, our customers and stakeholders, believe are the most important elements of the future energy landscape.

Currently, we do not have a clear vehicle in which all market participants can discuss and quantify future gas transmission network needs, future operational challenges and uncertainties. The *GFOP* will fill that gap (see Figure 1.1) and complement the *Gas Ten Year Statement (GTYS)* and our other Future of Energy suite of documents[1] (see section 1.2). We want to work with all interested parties to make sure that the right commercial options (rules), operational arrangements (tools) and physical investments (assets) are considered across the NTS.

We have a key role as gas System Operator and Transmission Owner in securing our energy future. The energy landscape in which we all operate is changing at an unprecedented rate.

The way we plan and operate the NTS needs to be more flexible to allow us to more quickly respond and adapt to both current and future changes.

[1] http://www2.nationalgrid.com/uk/industry-information/future-of-energy/

Figure 1.1
The role of the Gas Future Operability Planning document

Scenarios
We use our Future Energy Scenarios as the starting point for all our future network planning.

Assumptions
We need to make assumptions about the more uncertain elements of the future and which areas to focus on first e.g. areas of greatest uncertainty or impact on the future of gas, our network and customers.

Analysis
We then complete our network analysis based on the scenarios and assumptions we have made.

Network Impact
We then assess the impact and document what this could mean for our network and our customers. What problems we may encounter and what possible solutions there may be. Anything we decide to take further action on will be detailed in the GTYS.

Actions
What action we need to take now in our investments or processes etc.

The *GFOP* will allow you to:
- tell us what you think might happen
- tell us how your use of the NTS might change
- challenge our assumptions
- provide evidence for other areas we should look at
- explore options/opportunities for collaborative working.

The *GFOP* will then help us to:
- understand the impact
- identify and quantify operability risk
- quantify capability requirements
- discuss potential options (rules, tools and assets)
- provide a starting point for innovation and collaboration.

The *GFOP* will allow us to more clearly articulate:
- what operability issues we have identified
- their extent – localised or national
- when they are likely to occur
- what capability is required
- what potential options we are aware of
- what the consequences could be on our service.

In *GTYS* we will outline:
- how we are responding to these impacts
- what options we are taking forward
- what changes we are making to our decision-making processes
- what changes we are making to our operational processes and what the consequences could be on our service.

Executive summary

1.2
How does the *Gas Future Operability Planning* publication fit in?

National Grid has an important role to play in leading the energy debate across our industry and working with you to make sure that together we secure our shared energy future. As System Operator (SO), we are perfectly placed as an enabler, informer and facilitator. The SO publications that we produce every year are intended to be a catalyst for debate, decision making and change.

The starting point for our flagship publications is the ***Future Energy Scenarios (FES).*** The *FES* is published every year and involves input from stakeholders from across the energy industry.

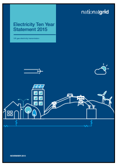
These scenarios are based on the energy trilemma (security of supply, sustainability and affordability) and provide supply and demand projections out to 2050. We use these scenarios to inform the energy industry about network analysis and the investment we are planning, which will benefit our customers.

For short-term challenges around gas and electricity transmission, we produce the ***Summer*** and ***Winter Outlook Reports*** every six months. We publish them ahead of each season to provide a view of gas and electricity supply and demand for the coming summer or winter. These publications are designed to support and inform your business planning activities and are complemented by summer and winter consultations and reports.

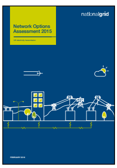
We build our long-term view of the gas and electricity transmission capability and operability in our *Future Energy Scenarios (FES), Ten Year Statements (ETYS* and *GTYS), Network Options Assessment (NOA), Gas Future Operability Planning (GFOP)* and *System Operability Framework (SOF)* publications. To help shape these publications, we seek your views and share information across the energy industry that can inform debate.

The *Gas Ten Year Statement (GTYS)* describes in detail what and where entry and exit capacity is available on the gas National Transmission System (NTS). The *GTYS* provides an update on projects we are currently working on. It also provides our view of the capability requirements and network development decisions that will be required for the NTS over the next ten years. If you are interested in finding out more about the longer-term view of gas capability and operability, please consider reading our *Future Energy Scenarios (FES)*, and *Gas Future Operability Planning (GFOP)* publications.

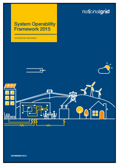
Our *Gas Future Operability Planning (GFOP)* publication describes how changing requirements affect the future capability of the NTS out to 2050. It also considers how these requirements may affect NTS operation and our processes. The *GFOP* may highlight a need to change the way we respond to you or other market signals. This, in turn, may lead us to modify our operational processes and decision making. This publication helps to make sure we continue to maintain a resilient, safe and secure NTS now and into the future. If you are interested in finding out more, please consider reading our *Future Energy Scenarios (FES)* and *Gas Ten Year Statement (GTYS)* publications.



The ***Electricity Ten Year Statement (ETYS)*** applies Future Energy Scenarios to network models and highlights the capacity shortfalls on the GB National Electricity Transmission System (NETS) over the next ten years. If you are interested in finding out about the network investment recommendations that we believe will meet these requirements across the GB electricity transmission network, please consider reading *Network Options Assessment (NOA)*. You can find out more about the longer-term view of electricity capability and operability by reading our *Future Energy Scenarios (FES)* and *System Operability Framework (SOF)* publications.



The ***Network Options Assessment (NOA)*** builds upon the future capacity requirements described in *ETYS* and presents the network investment recommendations that we believe will meet these requirements across the GB electricity transmission network. If you are interested in finding out more about electricity capability and operability, please consider reading our *Future Energy Scenarios (FES), Electricity Ten Year Statement (ETYS)* and *System Operability Framework (SOF)* publications.



The ***System Operability Framework (SOF)*** uses the Future Energy Scenarios to examine future requirements for the operability of GB electricity networks. It describes developments in operational needs and provides information that can help towards developing new technology, codes and solutions that improve system operability. If you are interested in finding out more, please consider reading our *Future Energy Scenarios (FES), Electricity Ten Year Statement (ETYS)* and *Network Options Assessment (NOA)* publications.

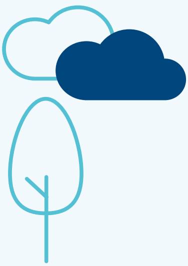
Executive summary

1.3
Key messages

Our assessment of the future will provide a detailed quantitative understanding of how your changing requirements may affect the capability and operability of the NTS. The higher level, more strategic, future of gas project will focus on the role the gas NTS will have going forward and how we can work together to adapt to this changing future.

Changing energy landscape

- Our direct connect customers (power stations, interconnectors, industrials, storage sites and entry terminals) want to be able to take gas off and bring gas on more quickly at shorter notice to respond to changes in the electricity market.
- Our distribution network customers want additional flexibility in how and when they take gas in order to meet their own customers' requirements.



- There is a notable trend towards later reconciliations of daily balancing by our more commercially responsive customers which depletes gas system stocks (volume of gas stored within the NTS).
- Longer-term capacity auctions no longer indicate a shipper's intention to flow. These auctions used to give us clear signals from the market that changes were required. We now have less certainty on the need to invest or take actions in advance to balance the network.
- Diversity and extent of supplies can mean a great variation of flow from one day to the next. This reduces the predictability of flows and requires greater operational flexibility to manage.
- Operationally we are seeing more rapid rates of change in the geographical distribution of supply and demand levels.
- There is an increasing magnitude of within-day gas system stock swings and they are, on average, treble the size of a decade ago with the largest swing of 38.5 mcm occurring in February 2015.

Future of gas[2]

- Gas plays a vital role today in providing secure energy supplies to our homes, businesses and industry. On an annual basis, gas provides 2.5 times as much energy (TWhs) as electricity which includes ~70% of heat.

- Gas will be crucial to continuing to provide a secure energy supply at best value for consumers while we transition to a low carbon future.
- We are committed to adapting our existing NTS infrastructure, operational processes and commercial agreements to ensure they remain the most efficient and reliable means of transporting gas from supply terminal to offtake.
- Gas will be required out to 2050 and beyond for domestic heating, industrial customers, power generation.
- We will continue to innovate and evolve the NTS as the UK progresses towards the 2050 targets. We are at the forefront of developing green gas solutions that aim to deliver value for money using the existing assets – for example project CLoCC[3] (customer low cost connections).

Gas and electricity interactions – Future energy generation[4]

- By 2040, between 15–38 GW of new combined cycle gas turbine (CCGT) capacity is expected to connect to the NTS (currently 28 GW).

- The way CCGTs operate is expected to become more unpredictable as their requirement to generate will correlate more with variable renewable generation (wind, solar etc.).
- CCGTs will be used more in combination with other electricity system balancing tools (interconnectors, storage, other generators and demand-side response).
- The volume of gas system stock swing attributable to CCGT operation has the scope to grow considerably into the future.
- The highest levels of CCGT swing are likely to occur when wind generation increases rapidly at the end of the gas day, coinciding with the reduction in total generation demand after the daily peak.
- Growing risk if fluctuations in renewable generation grow in magnitude and coincide with the start or end of the daily gas system stock swing.
- CCGT swing alone is unlikely to cause system operability challenges.

[2] http://futureofgas.uk/

[3] Project CLoCC website: http://projectclocc.com/

[4] FES 2016, http://nationalgrid.com/fes

Executive summary

1.4
Future *Gas Future Operability Planning* editions

This document is a building block for future *GFOP*s and provides an outline for what this document could look like.

We are keen to get your feedback on the topic we have focused upon in our first *GFOP* and on the analysis assumptions we have made. We have looked at CCGT within-day demand in isolation and in combination with other within-day variables to assess the impact on NTS operability and capability. Further work is required to look at more of the within-day variables in combination.

We want your input into future editions to ensure we are focusing on the most important elements of the future energy landscape from your perspective.

For future editions we could focus on assessing the impacts of one or more of the following topics:

- Commercially responsive supplies.
- Customers becoming more reliant on day ahead/within-day Exit bookings instead of long-term obligated capacity.
- Charging regime changes.
- Capacity and connection changes.
- Growing pressure to accept a wider range of gas quality on the NTS to boost security of supply.
- Clearer understanding of impacts of gas and electricity interactions on operability.

Let us know what you think, contact us:
.box.GFOP@nationalgrid.com

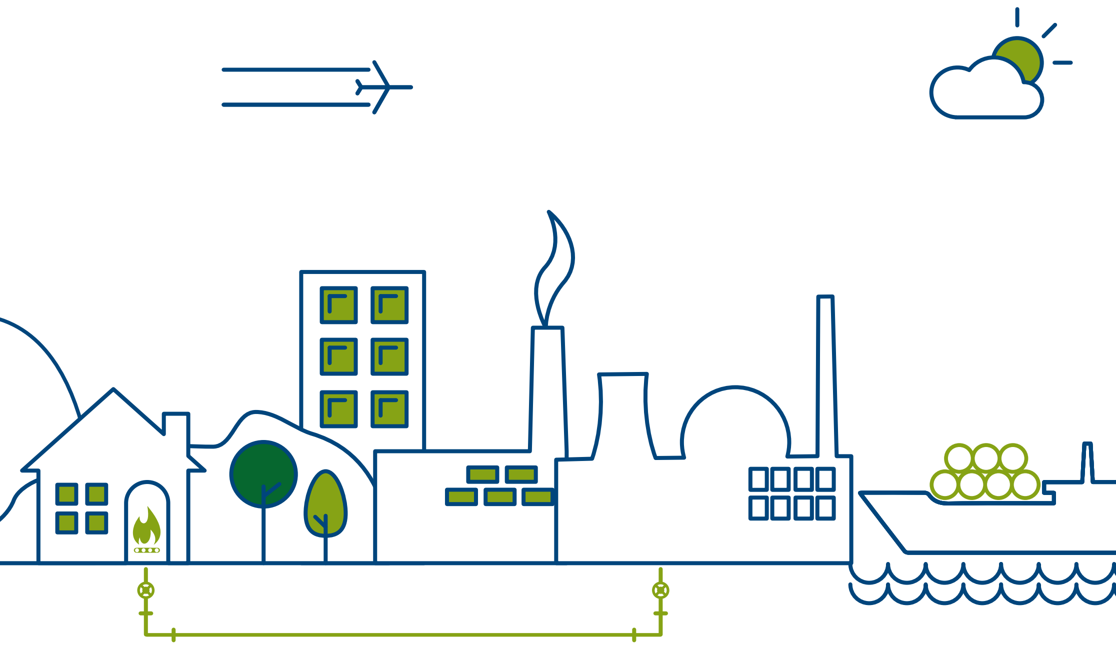
1.5

Next steps for the *Gas Future Operability Planning*

The timeline below outlines what we plan on doing next with the *GFOP*. The key next step is to get as much feedback from you as possible on this first draft. The *GFOP* will be published alongside our *Gas Ten Year Statement*.

We have already started talking to some of you at the Gas Futures Group, our Gas Customer Seminar and the Gas Transmission Working Group. We will be holding a consultation event in early 2017 where we will be seeking your views on the 2016 *GFOP* and we will be asking for your help with the development of our 2017 *GFOP*. Get in touch with us via **.box.GFOP@nationalgrid.com** if you would like to get involved. We will be asking you for opinions on the most appropriate way you would like us to engage with you going forward at this event.

Figure 1.2
Road map for the GFOP



Chapter two

Changing energy landscape

2.1
Changing energy landscape

The current and future direction of energy policy and the shape, size and mix of the energy network in the UK is increasingly uncertain; therefore we must consider the different roles gas can play in both the short and long term to understand how our role might change and how the use of our asset base may evolve.

There are some important choices to make about our priorities for investment and focus for innovation in order to provide long-term value for UK gas consumers and to ensure we continue to meet your needs.

Key insights

- Our direct connect customers (power stations, interconnectors, industrials, storage sites and entry terminals) want to be able to take gas off and bring gas on more quickly at shorter notice to respond to changes in the electricity market.
- Our distribution network customers want additional flexibility in how and when they take gas in order to meet their own customers' requirements.
- There is a notable trend towards later reconciliations of daily balancing by our more commercially responsive customers which depletes gas system stocks (volume of gas stored within the NTS).
- Longer-term capacity auctions no longer indicate a shipper's intention to flow. These auctions used to give us clear signals from the market that changes were required. We now have less certainty on the need to invest or take actions in advance to balance the network.
- Diversity and extent of supplies can mean a great variation of flow from one day to the next. This reduces the predictability of flows and requires greater operational flexibility to manage.
- Operationally we are seeing more rapid rates of change in the geographical distribution of supply and demand levels.
- There is an increasing magnitude of within-day gas system stock swings and they are, on average, treble the size of a decade ago with the largest swing of 38.5 mcm occurring in February 2015.

2.1.1
EU referendum

The recent European Union (EU) referendum decision does not change how we operate the UK energy system or security of supply. We are fully committed to our ongoing investment projects with our European partners and stakeholders. We believe our current Future Energy Scenarios (FES) provide a range of credible futures to cover a majority of the potential impacts that the UK's exit from the EU may have on the energy sector.

2.1.2
Government perspective on future power generation

The Government stated in November 2015 that "gas is central to our energy secure future" and that "it's imperative that we get new gas-fired power stations built"[1] within the next ten years to replace coal-fired power stations expected to close by 2025. It is important for us to understand what impact an increasing number of CCGT connections may have on the gas transmission network. We need to understand how many connections there are likely to be between now and 2025, where they are likely to connect and what system constraints, if any, we might face. This may allow us to identify more favourable areas on the network for future connections, which will ensure we can make use of and continue to adapt the transmission network to avoid any unnecessary investment, making the make best use of our current infrastructure assets.

38.5mcm

The largest within-day gas system stock change seen in February 2015. The average change in gas system stocks across a day is increasing and the magnitude of large within-day changes is increasing.

[1] Secretary of State for Energy and Climate Change speech, 18 November 2015: https://www.gov.uk/government/speeches/amber-rudds-speech-on-a-new-direction-for-uk-energy-policy

Changing energy landscape

Spotlight: Economic impact on generation mix

Despite the Government statement on energy policy in November 2015, the current economic conditions for thermal generators have resulted in earlier than anticipated plant closures, power station mothballing or reductions in capacity (~5 GW reduction in electricity transmission connected capacity in 2015/16). In May 2016, the UK's electricity was supplied without burning any coal for the first time. Falling power prices have made it increasingly uneconomical to run coal-fired power stations. The price difference between coal and gas is predicted to narrow over winter 2016/17. This may increase price competition between the two fuels, although gas-fired generation is still expected to have a cost advantage.

This could mean that coal-fired generation plant may close at a more accelerated rate than previously thought with closures possible by 2022 rather than 2025.

In the annual Autumn Statement, also in November 2015[2], the £1 billion ring-fenced competition funding for Carbon Capture and Storage (CCS) was removed. This is expected to delay CCS development in the UK. The Government's view is "that CCS has a potential role in the long-term decarbonisation of the UK" although "the detailed design and implementation of CCS policy changes have yet to be developed"[3]. The UK has committed to the legally binding target of reducing emissions by at least 80% from 1990 levels by 2050. To meet this target CCS, nuclear and renewable technologies are key to decarbonising electricity generation.

A study by the UK Energy Research Centre (2016)[4] concluded that without CCS, gas-fired power generation is not a viable long-term solution as although it emits less CO_2 than coal-fired generation it is not a low carbon option. Without CCS the 2050 target can be met but costs are estimated to increase by between 50 and 100 per cent[5]. The Government's decision to remove this funding has made the future of gas as a lower carbon alternative fuel more uncertain. There are also uncertainties associated with the long-term reliability of renewables; gas is currently the only viable alternative with a reliable track record.

[2] DECC Annual Autumn Statement 25 November 2015: http://www.londonstockexchange.com/exchange/news/market-news/market-news-detail/other/12597443.html

[3] Amber Rudd, Carbon Capture and Storage letter to Angus MacNeil, January 2015, http://www.parliament.uk/documents/commons-committees/energy-and-climate-change/DECC-CCS-announcement-SOS-TO-CHAIR.pdf

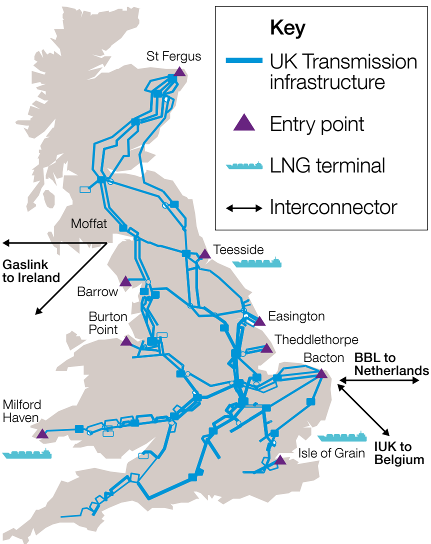
[4] UKERC (2016), The future role of natural gas in the UK: http://www.ukerc.ac.uk/publications/the-future-role-of-natural-gas-in-the-uk.html

[5] Energy Technology Institute (2014), http://www.eti.co.uk/wp-content/uploads/2014/03/3427-CCS-Brochure-Lores-AW----------Amended.pdf

2.2 National transmission system overview

The National Transmission System (NTS) is made up of 7,600km of pipelines, operated at pressures of up to 94 bar, which transport gas from coastal terminals and storage facilities to exit offtake points from the system (Figure 2.1). At the exit offtake points, gas is transferred to eight Distribution Networks (DNs) for onward transportation to domestic and industrial customers, or to directly connected customers including storage sites, power stations, large industrial consumers and interconnectors (pipelines to other countries).

Figure 2.1
Current NTS map



As GB gas transmission System Operator (SO) it is our responsibility to transport gas from supply points to exit offtake points safely, efficiently and reliably. We manage the day-to-day operation of the network including balancing supply and demand, maintaining system pressures and ensuring gas quality standards are met.

We outline our current understanding of your requirements in Chapter 2 of our *Gas Ten Year Statement (GTYS)*[6]. As part of the *GFOP* we want to get a better understanding of your future requirements of the NTS. Please get involved in our upcoming stakeholder engagement events (see Chapter 4) to let us know what your future requirements are. This will ensure the assumptions we are using as part of our future network planning process are appropriate and reflect your needs.

[6] http://nationalgrid.com/gtys

Changing energy landscape

2.3
What challenges are we currently seeing on the National Transmission System?

We are seeing a number of current challenges with:

1. system imbalances (within-day and end-of-day) which can lead to reductions in
2. gas system stock levels which in turn affects system pressures
3. short-notice changes in customer requirements at peak times of system maintenance.

The following sub-sections provide more detail on each of these elements. We have included two spotlights later on in this chapter which illustrates two recent challenging periods on the NTS: 5 September 2016 and July 2016.

2.3.1
System imbalances

Throughout a gas day, supply and demand are rarely in balance, so levels of gas stock within our system fluctuate. In our role as residual balancer of the GB gas market, we need to ensure an end-of-day market balance by ensuring total supply equals, or is close to, total demand. This ensures that system pressures and gas system stock levels are restored, ready for the start of the next gas day.

We look at the end-of-day market balance which is based on flow notifications provided by our customers. We use this information to determine if we need to take a balancing action to ensure the network is balanced at the end of day.

Our more commercially responsive customers are changing the way that they want to use our network. This includes a notable trend towards later daily balance reconciliations, along with start-of-day flow notifications that are less reflective of actual flows and end-of-day volumes. An example of the impact of this trend on the NTS is shown in the 5 September spotlight later on in this Chapter.

2.3.2
Gas system stock levels and system pressures

We manage levels of gas system stocks on a national and zonal level to ensure that NTS pressures remain within obligated operational and safety tolerances. The limits within which we can allow system stocks to change within-day are determined by the maximum operating pressures of our assets and the minimum contractual pressures that we have agreed with our customers.

The levels by which gas system stocks will change within-day in a zone of the NTS are driven by the difference between the levels and profiles of local supply and demand, plus the capability of the NTS to transport gas from zone to zone.

When gas is transported over long distances its pressure can drop significantly, which may mean that we are unable to meet the agreed minimum contractual pressures. As a result, supply patterns and within-day demand variation can significantly affect our ability to manage gas system stocks in a controlled way, to allow for the imbalance between supply and demand, while also allowing us to meet our contracted pressures.

Figures 2.2 and 2.3 compare the within-day gas system stock level changes seen in 2002/03 to those seen in 2015/16. It illustrates that current gas system stocks changes at certain times of the year are up to three times the level seen a decade ago. This trend of increased volatility is leading to greater operational challenges, particularly in terms of managing NTS pressures and ensuring that they remain within safety and contractual tolerances.

Gaining a better understanding of the different component parts to gas system stock swings will allow us to quantify what levels of swing pose more of an operational challenge to the NTS and if there are particular sources of system swing which have more of an impact on operability.

Chapter two

Changing energy landscape

Figure 2.2
Within-day maximum to minimum range of NTS gas system stock levels

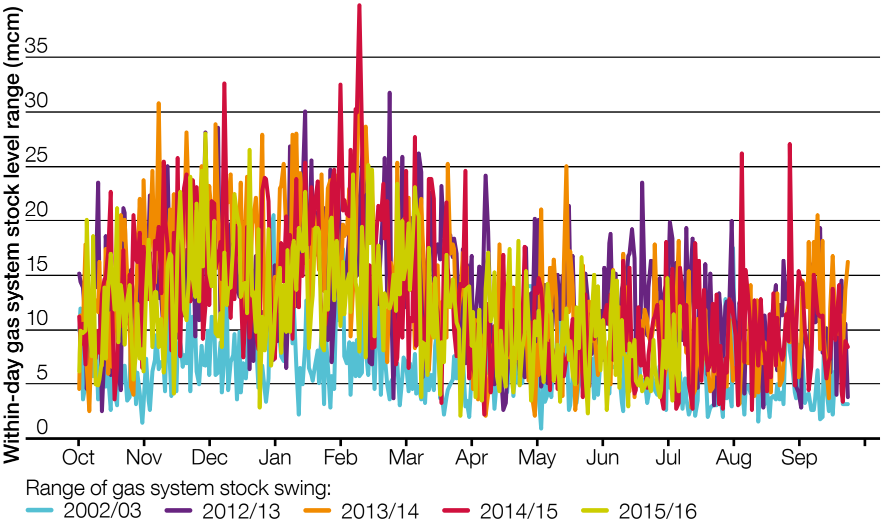


Figure 2.3
Rolling 30-day average range of NTS gas system stock levels

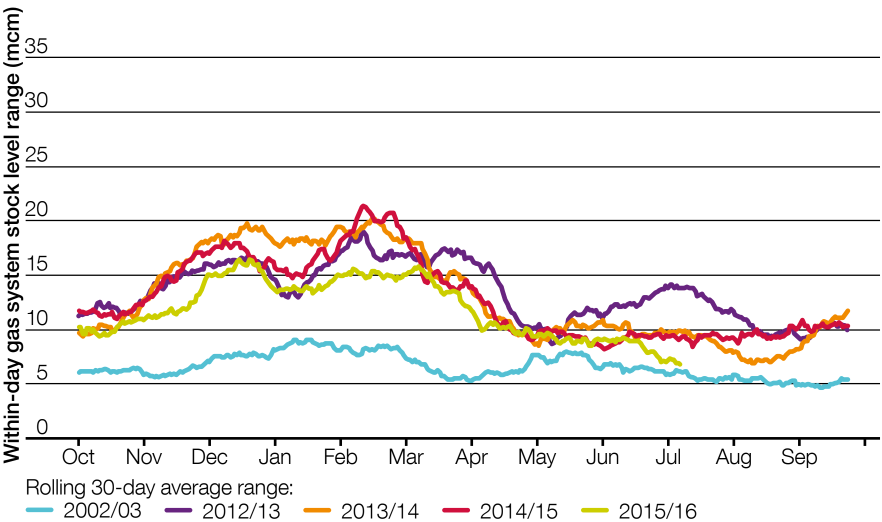


Table 2.1 shows the number of instances where within-day gas system stocks swing has been greater than a certain level of mcm per day.

Table 2.1
Number of instances where within-day gas system stock swing has fallen within a particular mcm range

	2002/03	2005/06	2007/08	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
10–15mcm	24	61	78	167	175	216	199	203	127
15–20mcm	4	16	11	63	70	107	114	90	51
20–25mcm	–	–	–	16	13	29	47	42	15
25–30mcm	–	–	–	3	3	6	8	10	3
30–35mcm	–	–	–	–	–	–	–	2	–
>35mcm	–	–	–	–	–	–	–	1	–

Since 2010 there has been an increasing trend in within-day gas system stock swings greater than 20mcm. This amount of within-day change in gas system stocks makes it more challenging from an operational point of view to move gas around the system to absorb any shortfalls. This year, there has been a better alignment of within-day supply and demand profiles which resulted in lower average daily gas system stock swings over the 2015/16 winter period (Figure 2.4), reversing the trend seen in recent years. We also experienced our mildest winter in almost sixty years which meant demand was consistently lower. However our biggest concern, from an operability perspective, relates to the magnitude of the events rather than the number of instances. Higher magnitude events pose more of an operability challenge as more action is required to move gas around the system to mitigate the swing event. The system needs to be flexible to ensure we can react quickly to respond to these events.

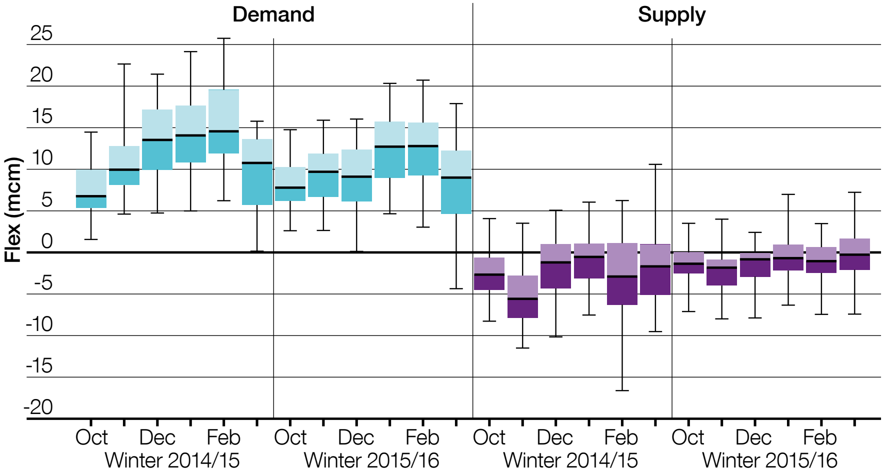
3 times
10–35mcm

Current gas system stock level changes are up to three times the level seen a decade ago.

Chapter two

Changing energy landscape

Figure 2.4
Within-day supply and demand swings in winter 2014/15 and winter 2015/16



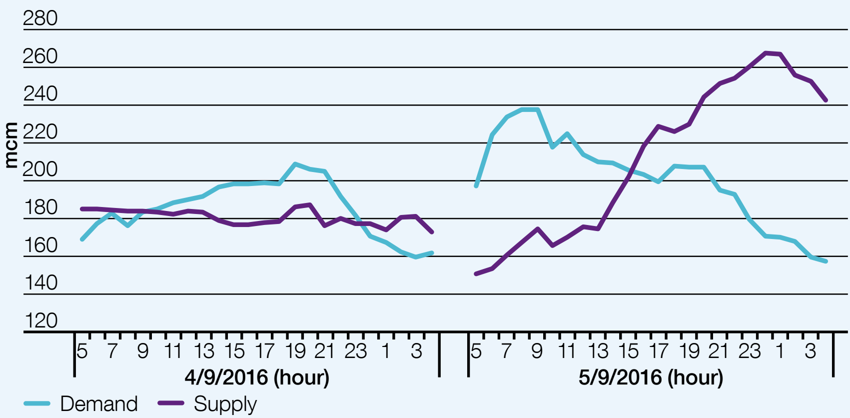
Although the *GFOP* is focused on future operability requirements we need to understand what operability challenges we are seeing on the system now. We can use the key learning points from these challenging days to develop our future resilience strategy and develop an understanding of what these types of day could mean for us in a future operating environment.

Spotlight: 5 September 2016

On 5 September 2016 the amount of gas in the National Transmission System (NTS) was at its lowest level since 2012. With less gas in the system our customers across the system were experiencing lower pressures than normal. For the first time since early 2012 we had to take commercial locational energy actions to ensure we met all of our contractual obligations.

The low levels of gas in the system was driven by market behaviour; there was a 50 mcm shortfall between gas coming into the NTS and gas going out of the NTS on a national demand of approximately 200 mcm at the start of the day. We had a limited response to our early trading from the market. **We've already started to engage with shippers to try to get a better understanding of their drivers in this type of situation.**

Figure 2.5
Supply and demand profiles on 4 and 5 September



Changing energy landscape

So what happened?
Sunday 4 September
The market was approximately 6 mcm light and this was compounded by late supply losses at St Fergus and Bacton terminals.

The Gas National Control Centre (GNCC) took a trade action but there was an insufficient response from the market which meant the amount of gas in the NTS fell to 326 mcm by the close of the gas day.

Monday 5 September
National challenge
The market opened 47 mcm light, meaning there was more gas going out of the NTS than was coming in, leading to a reduction in the overall amount of gas in the NTS. Demand was increasing by approximately 3 mcm per hour which meant that by 9:00am the amount of gas in the system was at 313 mcm and still falling.

With the amount of gas in the system continuing to fall and limited market response, GNCC traded in order to stimulate the market to respond by either reducing demand or increasing supply.

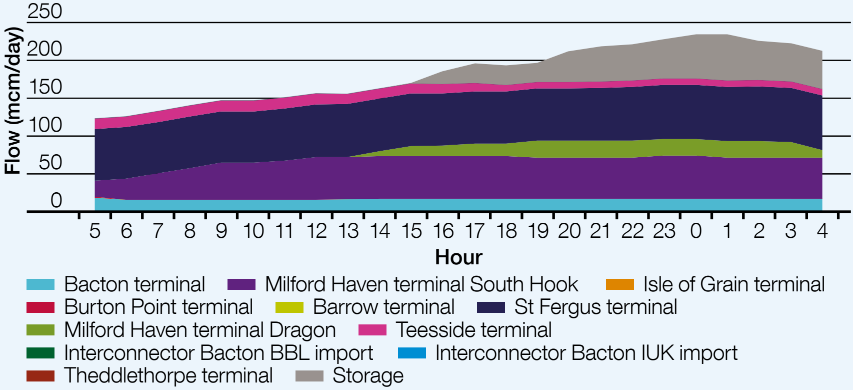
A market response was seen at 10:00am, with storage site injection (gas demand) reducing, however there was still a significant shortfall between supply and demand.

A second trade action was taken by GNCC at 1:00pm and Dragon, one of the Milford Haven sub-terminals, started flowing.

A further GNCC trade was taken at approximately 2:00pm and the market responded with storage sites withdrawing (gas supply). This response started to address the national balance position.

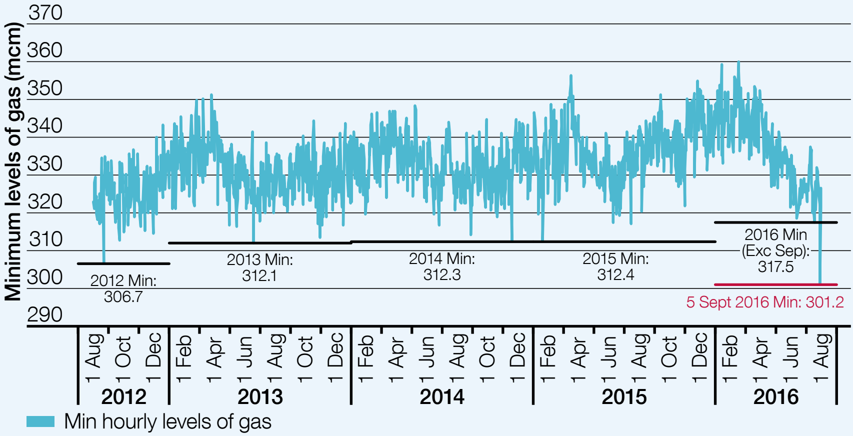
We received calls from power stations, Distribution Networks and IUK during the day as they were querying the lower than usual pressures. We didn't breach any of our contractual obligations with our customers, however the lower than usual pressures were a concern so we outlined why it was happening and what we were doing about it.

Figure 2.6
Supply mix on 5 September



The amount of gas in the system reached its lowest level at 3:00pm, 301 mcm. From this point on, there was more gas coming into the NTS than going out and the amount of gas in the NTS increased.

Figure 2.7
Historic minimum levels of gas in the NTS



Locational challenge

The increase in supply flow at Dragon in South Wales resulted in a locational pressure challenge for the NTS. There was a planned compression outage at Churchover compressor station on 5 September.

On 5 September the South Hook sub-terminal at Milford Haven was already flowing 50 mcm. The increase in the Dragon supply rate meant that the capability of the NTS to move gas away from Milford Haven was going to be exceeded, leading to a localised pressure constraint situation in South Wales.

To mitigate this GNCC requested the return to service of Churchover compressor station. The initial estimate of return to service time for Churchover compressor station was 3:00am on 6 September, but the site team managed to bring it back online by 6:00pm on 5 September. Both Churchover and Wormington compressor stations were then used to allow the movement of more gas out of South Wales.

Even with compression being available our network analysis showed that with the prevailing conditions, the pressure at Milford Haven would reach the maximum operating pressure (MOP) limit at approximately 11:30pm. This meant location specific actions were required to prevent this from happening. It takes a few hours for this process to take effect. The initial action taken before 6:00pm scaled back interruptible entry capacity at Milford Haven.

Changing energy landscape

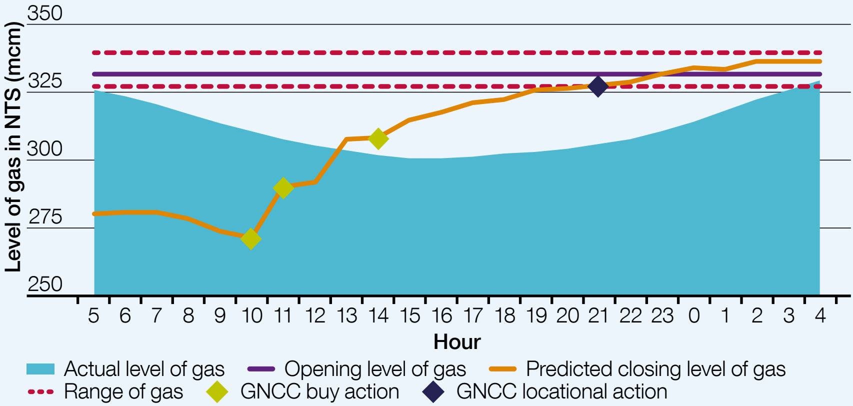
A request for locational energy bids was then sent out to the market. A response was received so the GNCC sold gas locationally.

This meant that the additional local demand effectively absorbed more of the gas in the area which reduced the amount that needed to be transported away. This helped to minimise the size of the constraint.

South Hook also reduced its flow rate slightly after midnight and together, this ensured that pressure peaked below the MOP limit of the pipeline.

From 5:00am Dragon came off and the pressure dropped.

Figure 2.8
NTS gas levels on 5 September with key commercial actions taken during the day



2.3.3
Short-notice changes in customer requirements at peak times of system maintenance

Every year we produce our winter and summer maintenance plans which we publish on our website to let you know where and when we will be doing maintenance works on the NTS[7]. We use these documents to keep you informed of the impact these works may have on the NTS, and any associated impact on entry or exit capacity. Where this work affects the capability at an Aggregate System Entry Point (ASEP), an indication of the revised ASEP's minimum daily capability is included for each month.

[7] http://www2.nationalgrid.com/uk/industry-information/gas-transmission-system-operations/maintenance/

Spotlight: July 2016, St Fergus high flows during a peak maintenance period

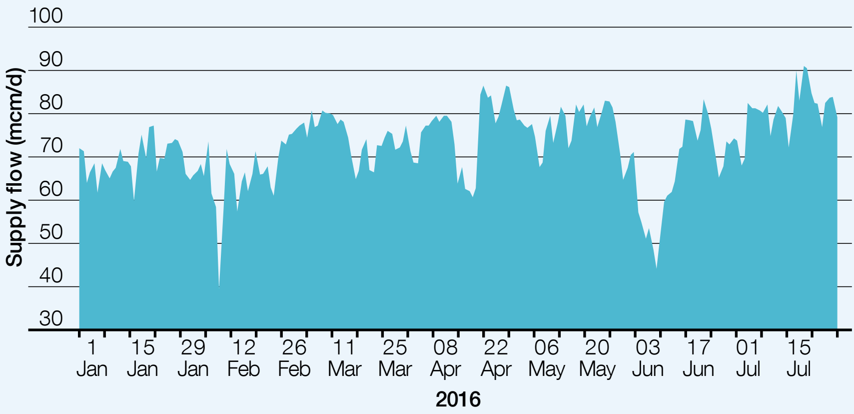
We issued our summer maintenance plan on 31 March 2016. As demand is lower in summer we tend to schedule more of our maintenance activities during this period. Flows coming in at supply terminals also tend to be lower as less gas is needed to meet demand.

During July and August works were planned at a number of compressor stations in Scotland and the northern half of the network. These compressors are used to move gas brought in at St Fergus to where it is required to meet demand.

We also had planned maintenance work on one of our main pipelines in Scotland between Bathgate and Glenmavis during the same time period. These works limited the capability of the compressor station at Avonbridge. As a result of these planned works we issued an ASEP capability notice for St Fergus in our summer maintenance plan for July of 83 mcm/d and for August of 82 mcm/d.

In June supply at St Fergus dropped to below 50 mcm/d, however in mid-June supply from the terminal ramped up reaching levels over 90 mcm/d by mid-July (see Figure 2.9).

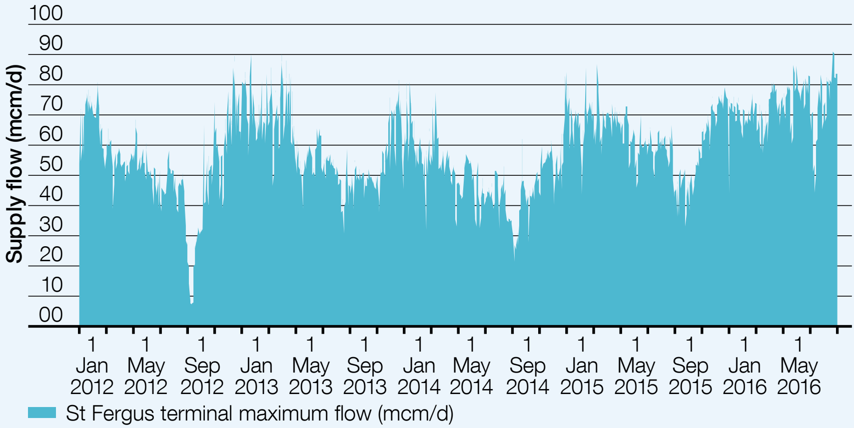
Figure 2.9
St Fergus terminal supply flows between January and July 2016



Changing energy landscape

During July and early August St Fergus was providing more than 50% of the UK's gas, which has not been seen for almost a decade. We had expected flows of between 55–65 mcm/d over June, July and August based on historic summer behaviour at the site (see Figure 2.10). We had sufficient resilience in place to deal with flows up to 83 mcm/d, however once flows went above this level action was required.

Figure 2.10
St Fergus terminal supply flows between January 2012 and July 2016



As we had several compressors in Scotland on outage, as per the planned maintenance schedule, there was a risk that there may be a flow constraint at St Fergus and a breach of the statutory pressure limits. To prevent this from happening we cancelled the scheduled works at several of our compressor stations to bring them back online. This provided sufficient resilience on the system to manage the higher than anticipated flows for the time of year at St Fergus.

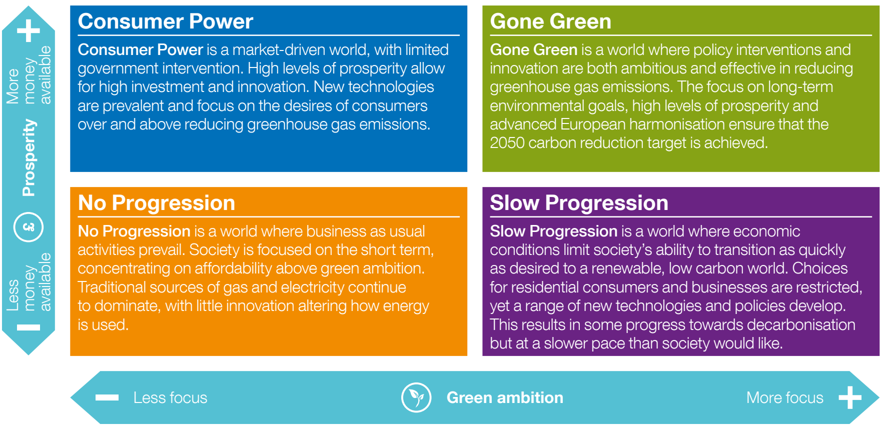
We've already started to engage with the delivery facility operators at St Fergus to try to get a better understanding of how we can ensure we continue to meet their ongoing requirements even during periods of peak maintenance.

2.4
What are our Future Energy Scenarios showing us?

Gas plays a vital role today in providing secure energy supplies to our homes, businesses and industry. On an annual basis, gas provides 2.5 times as much energy (TWh) as electricity, which includes ~70% of heat. Our view is that gas will be crucial to continuing to provide secure energy supply at best value for consumers while we transition to a low carbon future.

Our *Future Energy Scenarios (FES)* indicate that the behaviour of CCGTs is expected to become more unpredictable as their requirement to generate will be more closely linked with renewable generation output and their interaction with other electricity network balancing tools (interconnection, storage, other generation and demand-side response).

Figure 2.11
The 2016 Future Energy Scenarios matrix



Based on our *FES*[8], we know that despite a decline in annual gas demand across three of the four scenarios (Table 2.2), our end consumers will continue to use gas out to 2050 for domestic heating, industrial processes and power generation[9]. Based on the technology currently available, the high temperatures used by heavy industry in the UK will be difficult to fully electrify so our assumption, for now, is that gas demand out to 2050 for this sector is expected to remain largely the same. In the **No Progression** scenario gas demand

[8] Future Energy Scenarios (2016): http://fes.nationalgrid.com/

[9] Page 154, Future Energy Scenarios (2016): http://fes.nationalgrid.com/

Changing energy landscape

is expected to increase slightly by 2050 with a majority of domestic users still reliant on gas and a large proportion of electricity generation coming from CCGT generators. Even the lower demand levels in the **Gone Green** scenario will still warrant the need for the NTS to transport gas nationwide to meet this ongoing demand in 2050. We already have the network infrastructure to supply gas, so it is more affordable for household and business consumers to use existing assets rather than build new ones.

Table 2.2
Forecast annual demand levels across all four FES out to 2050

Gas Year	Gone Green TWh	Slow Progression TWh	No Progression TWh	Consumer Power TWh
2015	809	809	809	809
2020	732	737	775	745
2025	663	660	748	695
2030	618	595	743	644
2035	647	579	756	637
2040	710	582	782	626
2045	725	650	904	740
2050	654	649	951	786

Data from *FES* 2016 charts (Figure 5.2.10)

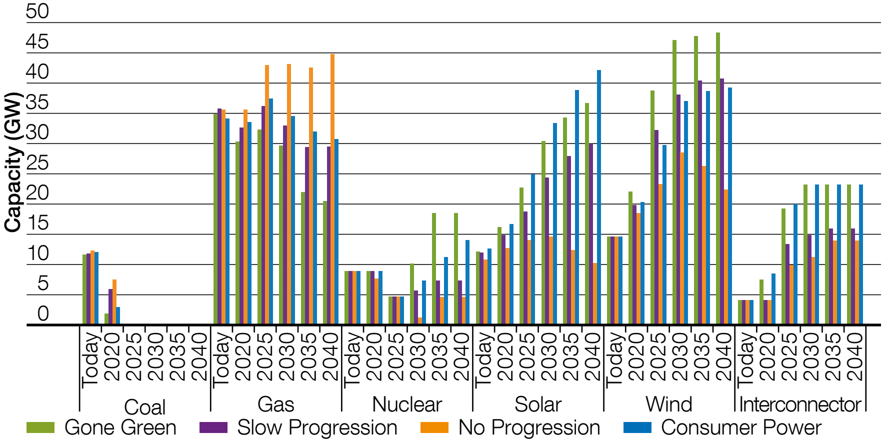
The Government statement on energy policy made in November 2015 indicated the importance of gas in our energy future. The statement infers that energy policy may favour investments made to develop CCGT generation capability. A majority of the current CCGTs are connected to the NTS. The NTS offers new power stations flexibility in terms of connection location, ramp rates and notice periods (see our *Gas Ten Year Statement (GTYS)*[10] for more information).

76%

By 2040 in our **No Progression** scenario, 76% of homes in the UK will still use gas for all or part of their heating.

[10] http://www.nationalgrid.com/gtys

Figure 2.12
Levels of coal, gas, nuclear, solar, wind and interconnector capacity



Data from *FES* 2016 charts (PS1, 3, 5 and 7)

The drive towards a decarbonised future makes nuclear, wind and solar the generators of choice, however gas will be a critical fuel to balance electricity demand. Figure 2.12 illustrates the levels of coal, gas, nuclear, solar, wind and interconnector capacity out to 2040/41.

The figure above indicates that the level of required gas generation capacity[11] is likely to increase across three of the four scenarios by 2025/26 as coal-fired generators close to comply with the Industrial Emissions Directive (IED). The **No Progression** scenario has by far the largest capacity increase from 2015 levels of 36 GW to 45 GW by 2040/41.

The figure also highlights the significant increase anticipated in both solar and wind by 2040/41 in all four scenarios. The behaviour of CCGTs is expected to become more unpredictable as their requirement to generate will be more closely linked with renewable generation output and their interaction with other electricity network balancing tools (interconnection, storage, other generation and demand-side response). As SO we need to have a clear understanding of what impact this more unpredictable behaviour may have on our network and what we can do to minimise the risk (see chapter 3).

We will continue to innovate and evolve the NTS so that the network continues to play a key role in the provision of energy as the UK progresses towards the 2050 targets.

We are starting to develop green gas solutions that aim to deliver value for money through using the existing networks – for example project CLoCC[12] (customer low cost connections).

[11] Gas capacity includes CCGT, open cycle gas turbines (OCGT) and combined heat and power (CHP) requirements.

[12] Project CLoCC website: http://projectclocc.com/

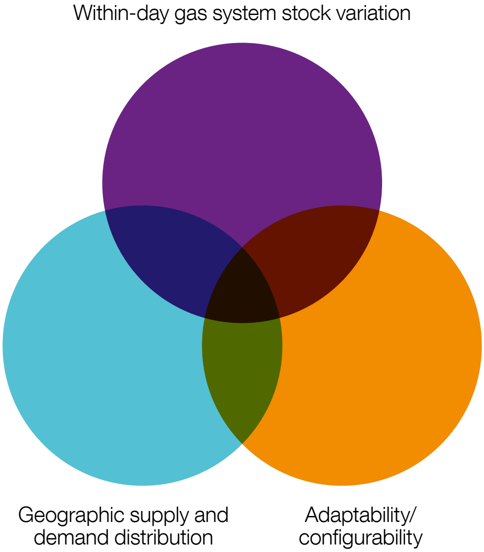
Changing energy landscape

2.5
System flexibility

We need to ensure the NTS is:
- able to adapt to changing daily supply and demand profiles and imbalances by varying gas system stock levels and system pressures
- able to cater for supply and demand levels which occur away from the 1-in-20 peak demand level but result in network flows in some parts of the network that are higher than would occur at the 1-in-20 demand level
- able to cater for the rate of change in the geographic distribution of supply and demand levels. This results in changes in the direction and level of gas flow through pipes, compressors and multi-junctions, and may require rapid changes to the flow direction in which compressors and multi-junctions operate.

Finding the right balance of the above will ensure the NTS is sufficiently flexible to meet future supply and demand requirements (Figure 2.13).

Figure 2.13
System flexibility requirements



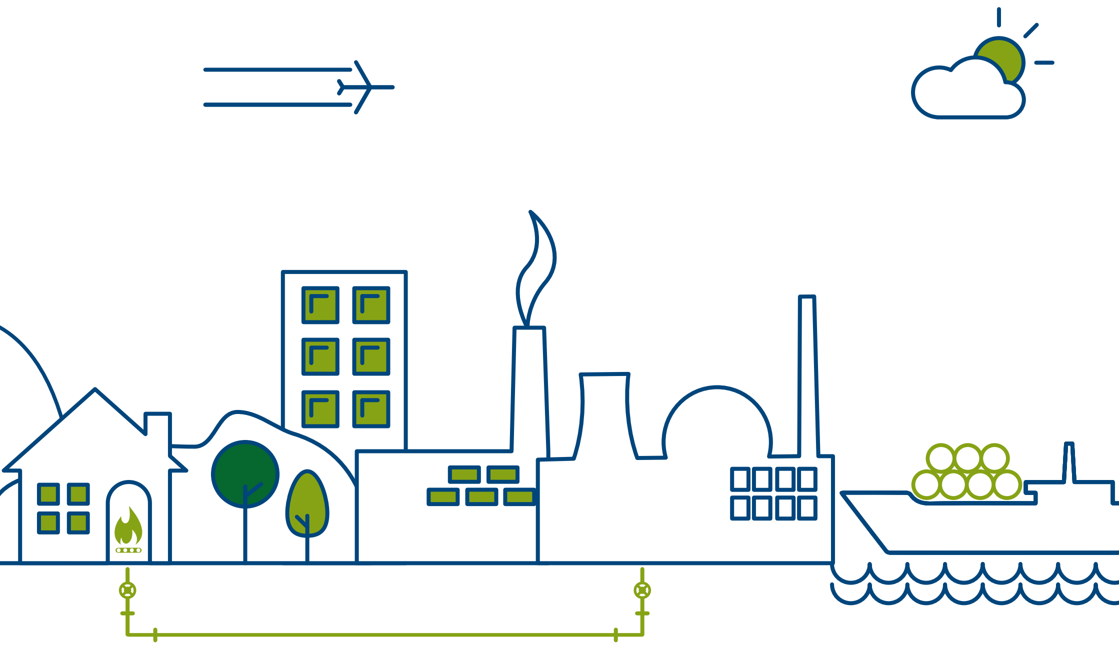
The within-day supply and demand patterns we are seeing on the gas NTS are very different from those envisaged when it was originally designed. The NTS now needs the ability to quickly adapt to changing daily supply and demand profiles and imbalances leading to varying system gas stocks and system pressures.

Our current Network Development Process (NDP) does not have a trigger mechanism to enhance system capability in response to changing and/or reducing flows of gas in the network, i.e. the net impact of a number of different customers changing their use of the NTS. The current regime is based on the concept of user commitment to provide incremental capacity[13]; however, this cannot always be the case when the way that capacity is used changes. The longer-term capacity auctions, which used to provide us with a clear market signal of intent, no longer indicate a customer's intention to flow gas. This means we have less certainty on the need to invest or when we need to take actions to change the way we operate.

We want to work with you to make sure that the right commercial options (rules), operational arrangements (tools) and physical investments (assets) are considered across the NTS. Our role is to balance your needs with the ability of the NTS to respond while minimising the cost to the end consumer.

[13] Incremental capacity is firm capacity made available over and above baseline in response to market demand and supported by user commitment.

Chapter **two**



Chapter three

Gas and electricity interactions – Future energy generation

3.1 Gas and electricity interactions – Future energy generation

Key insights

- By 2040, between 15–38 GW of new combined cycle gas turbine (CCGT) capacity is expected to connect to the NTS (currently 28 GW).
- The way CCGTs operate is expected to become more unpredictable as their requirement to generate will correlate more with intermittent renewable generation (wind, solar etc.).
- CCGTs will be used more in combination with other electricity system balancing tools (interconnectors, storage, other generators and demand-side response).
- The volume of gas system stock swing attributable to CCGT operation has the scope to grow considerably into the future.
- The highest levels of CCGT swing are likely to occur when wind generation increases rapidly at the end of the gas day, coinciding with the reduction in total generation demand after the daily peak.
- Growing risk if fluctuations in renewable generation grow in magnitude and coincide with the start or end of the daily gas system stock swing.
- CCGT swing alone is unlikely to cause system operability challenges.

As we mentioned in section 2.5, the 2016 *FES* indicates the range of expected new CCGT capacity connection requirements by 2040 (from 15 GW in the **Gone Green** to 38 GW in the **No Progression** scenarios). With such a wide range in potential generation capacity requirements it is more of a challenge to appropriately plan the network for the future.

The behaviour of CCGTs is expected to become more unpredictable as their requirement to generate will be more closely linked with renewable generation output and their interaction with other electricity network balancing tools (interconnection, storage, other generation and demand-side response).

We need to assess what impact this changing customer requirement may have on our future network capability and operability. This will help us to clearly articulate and quantify any operability risks. We can then work with you to identify any possible opportunities to minimise the impacts and risk.

By 2040

CCGT capacity is expected to range from 15 GW to 38 GW

3.2
Analysis results summary

Our initial analysis has focused on understanding the potential impact of increasing volumes and within-day volatility of CCGT generation on the NTS, under a range of possible futures as described by the FES. The assumptions, methodology used and detailed analysis results are provided in Appendix 1. The results are summarised below.

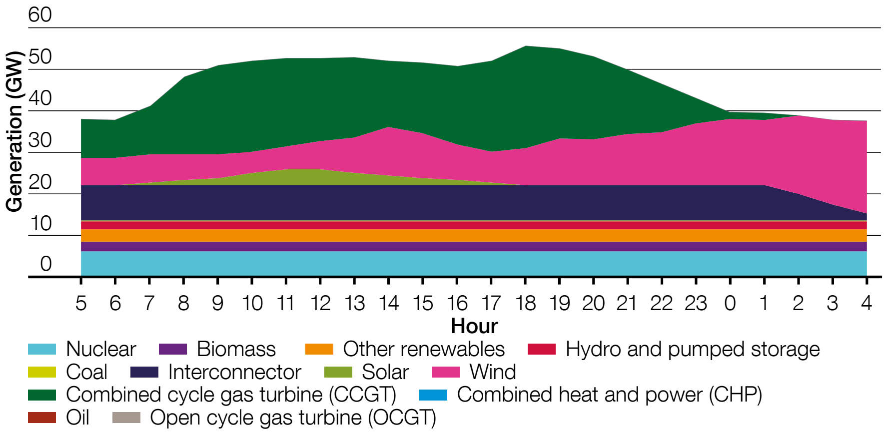
Figure 3.1
Analysis assumptions overview

Modelling	■ 2017, 2023, 2030 ■ All four Future Energy Scenarios (GG, SP, NP, CP) ■ Wind year 2007 ■ Cold weather variable ■ Flag – single highest CCGT swing day ■ Within-day supply and demand profile changes.
Demand	■ Constant Distribution Network profile (level varies with FES scenario) ■ New power station locations based on the Transmission Entry Capacity (TEC) register (where possible) or based on sites of former coal-fired power stations near to the NTS ■ Winter's day chosen to simulate short period for solar generation ■ Wind profile chosen to simulate windy day ■ Merit order applied with CCGTs set as the flexibility generator of choice ■ Nuclear, biomass, other renewables and coal are constant throughout the day.
Supply	All supplies based on FES: ■ Flat supply ■ Start-of-day shortfall 22 mcm/d, supplies profiled to address shortfall by end of day ■ Start-of-day shortfall 44 mcm/d, supplies profiled to address shortfall by end of day.
Asset	■ Full and intact network ■ Network as-is today plus known planned changes.

Gas and electricity interactions – Future energy generation

The output of our modelling indicates that the volume of gas system stock swing attributable to CCGT operation has the scope to grow considerably into the future. The highest levels of CCGT swing generated occurred when the output of wind generation increased rapidly at the end of the gas day, coinciding with the reduction in total generation demand after the daily peak (Figure 3.2).

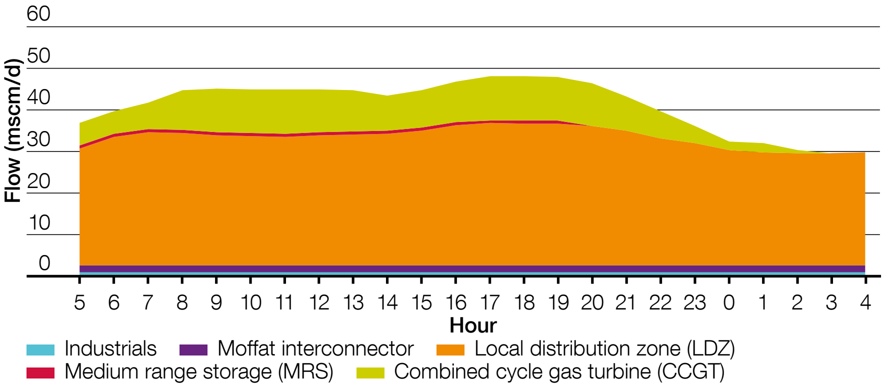
Figure 3.2
Power market model hourly electricity generation profiles (2023 Consumer Power – High CCGT swing day – CCGT and wind generation)



It could also be possible for the converse to happen, i.e. for renewable generation to fall at the start of the morning peak causing a high rate of increase in the requirement for CCGT generation, although this should normally be, at least partially, offset by the pattern of solar output.

We already see a significant contribution to gas system stock swings as CCGT demand profiles tend to coincide with the daily demand from Distribution Networks. Our analysis shows this has the potential to increase further if fluctuations in renewable generation continue to grow in magnitude and coincide with the start or end of the daily swing (Figure 3.3).

Figure 3.3
Modelled hourly demand flows (2023 Consumer Power – High CCGT swing day)



In terms of the impact of this growth in CCGT swing on our ability to operate the NTS, our initial analysis has identified relatively few scenarios in which CCGT swing in itself, even under the relatively testing assumptions that we have made in some areas, causes constraints if supplies are delivered to the NTS at a steady rate. However when moderate or high levels of supply profiling are applied, more constraints are identified, affecting our ability to deliver our pressure obligations both on exit and on entry (see Appendix 1 for more detail).

It is important to note that these results are based on a small number of gas days analysed and are based on a full, intact network. Our next steps are outlined in the following section and will involve more comprehensive modelling and results validation. Changes to the assumptions that have been made in other areas, such as the amount of flexibility taken by Distribution Networks, could affect these results significantly.

Gas and electricity interactions – Future energy generation

3.3
What next for our analysis?

This is the first analysis assessment of the NTS based on supply and demand profiling. This represents part of our ongoing work to develop our ability to assess and quantify system flexibility. We are considering a range of next steps which include:

- external consultation on the assumptions made in the analysis completed to date
- building upon our understanding of system flexibility requirements to identify and quantify any impacts on future operability
- a range of sensitivities could be considered for further analysis, for example relating to supply responsiveness, outages, future asset decommissioning etc
- developing our ability to forecast gas system stock swing by considering other factors such as flexibility requirements from Distribution Networks
- continuing to carry out detailed historic analysis of system flows, gas system stocks and pressure as well as other relevant market variables to validate and calibrate our projections.

Chapter four

Next steps

4.1 Next steps

This is a first draft of this document for your review and comment. We are keen to hear your views so this document can evolve and focus on what you, our customers and stakeholders, believe are the most important elements of the future energy landscape. Our aim is for future editions of this document to be more collaborative so all interested parties can highlight changes which will require us to quantify the effect on the future NTS capability and operability.

The timeline opposite outlines what we plan on doing next with the *GFOP*. The key next step is to get as much feedback from you as possible on this first draft.

We have already started talking to some of you at the Gas Futures Group, our Customer Seminar and the Gas Transmission Working Group.

We will be holding a consultation event in early 2017 where we will be seeking your views on the 2016 *GFOP* and we will be asking for your help with the development of our 2017 *GFOP*.

Get in touch with us via **.box.GFOP@nationalgrid.com** if you would like to get involved. We will be asking you for opinions on the most appropriate way you would like us to engage with you going forward at this event.

Figure 4.1
Road map for the GFOP

This document is a building block for future *GFOP*s and provides an outline for what this document could look like.

We are keen to get your feedback on the topic we have focused upon in our first *GFOP* and on the analysis assumptions we have made.

For future editions we could focus on assessing the impacts of one or more of the following topics:

- Commercially responsive supplies.
- Customers becoming more reliant on day ahead/within-day Exit bookings instead of long-term obligated capacity.
- Charging regime changes.
- Capacity and connection changes.
- Growing pressure to accept a wider range of gas quality on the NTS to boost security of supply.
- Clearer understanding of impacts of gas and electricity interactions on operability.

Let us know what you think, contact us:
.box.GFOP@nationalgrid.com

Chapter five

Appendix 1
Analysis assumptions and methodology

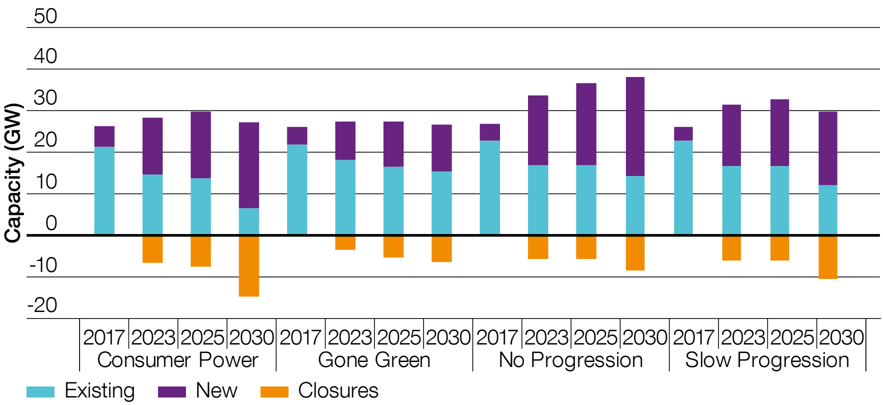
5.1
Analysis assumptions

We have created a number of scenarios designed to test the ability of the NTS to accommodate higher volumes of CCGTs on the network.

5.1.1
Power Market assumptions

Our Power Market assumptions are consistent with those made in each of our Future Energy Scenarios (FES). Each scenario makes assumptions about the total CCGT generation capability available together with the size and location of each individual CCGT that will be connected to the NTS, based on a range of information such as entries in the Transmission Entry Capacity (TEC) register. In scenarios where the level of CCGT capability is very high, there is insufficient information available to make an informed decision as to the location of all new CCGTs. In these instances, it has been assumed that the required CCGTs will be located on the sites of former coal-fired stations close to the NTS.

Figure 5.1
Connected CCGT capability under different FES



5.1.2
Demand assumptions

The assumptions that have fed into the initial phase of our analysis have been selected not only to reflect the range of outcomes that might be possible under FES, but also to apply more demanding requirements on the network to identify any possible constraints.

We have considered all four Future Energy Scenarios – **Gone Green**, **Consumer Power**, **Slow Progression** and **No Progression** – for three gas years – 2017/18, 2023/24 and 2030/31. The data for electricity demand and generation capacity are consistent with FES for each of these scenario/year combinations[1].

We have assumed a seasonal cold gas demand and applied a 'windy' profile taken from 2007 (the windiest recent year) to increase the amount of volatility due to wind.

5.1.3
Supply assumptions

Normally our network analysis assumes that supplies are 'flat', i.e. gas comes on to the NTS at a constant rate such that the aggregate level of supply in each hour of the gas day is equivalent to 1/24th of the end-of-day demand for that day. Although this is consistent with the obligations on supplies to flow at a flat rate, there are a number of reasons why this is not necessarily an accurate assumption for planning purposes:
- Shippers do not have perfect knowledge of end-of-day demand and their initial forecasts may be inaccurate due to fluctuations in a range of factors including weather, market conditions, etc.
- Supply losses close to the start of the day.
- Commercial and operational considerations.

We have analysed the amount of supply profiling on historical gas days where there was a gas system stock swing greater than 25 mcm/d. This showed a wide range of supply profiles, ranging from an 81 mcm/d shortfall and a 36 mcm/d surplus at the start of the gas day with an average 21 mcm/d shortfall. The 5th percentile, representing a start of day shortfall of 44 mcm/d, was chosen as a 'high supply swing' supply profile representing a credible high case.

Adopting a 'high supply swing' supply profile puts the network under more stress by increasing the rate of gas system stock depletion earlier on in the gas day. It has been assumed that the system will return to a full supply balance by the end of the gas day in two steps, whereby half the shortfall is added to supplies at 8pm and the remaining half is added at 12 midnight. These times have been selected as they represent the most frequent hour bars at which the Gas National Control Centre take balancing actions to resolve a national supply deficit.

[1] CCGT locations are consistent with each FES. In some instances it was necessary to make assumptions about the locations of specific CCGTs where there was insufficient information available. In these cases, additional CCGTs were allocated to sites of existing coal-fired power stations close to the NTS.

Appendix 1
Analysis assumptions and methodology

5.2
Analysis methodology

5.2.1
Analysis setup

We generated thousands of gas days for each of the 12 combinations of gas year and FES. In each run, the Power Market Model generated hourly electricity demands; generation plant was then despatched via a merit order to create hourly generation profiles by unit. These were fed into the Gas Market Model to create an overall gas demand with a supply match.

For each of the 12 gas year/FES combinations, a single gas day with the highest volume of CCGT swing was selected to progress to the network analysis stage. Each of these gas days was analysed up to three times:

1. with a ‘flat supply’ profile
2. with a ‘high supply swing’ supply profile (start-of-day shortfall of 44 mcm/d)
3. with a ‘medium supply swing’ supply profile (start-of-day shortfall of 22 mcm/d).

The ‘medium supply swing’ supply profile was only analysed if the network was unable to support the ‘high supply swing’ supply profile’ to assess if the network was capable of accommodating a medium supply swing.

5.2.2 Analysis focus

This analysis focused on:
- the ability to meet Assured Offtake Pressures (AOPs)
- pipeline Maximum Operating Pressures (MOPs)
- the impact on compressor flows and configurations, and
- the impact on local and national gas system stock levels.

Assured Offtake Pressures are the minimum offtake pressures required to maintain security of supply to our Distribution Network (DN) customers. Failure to meet these pressures is caused either by a shortfall in supply at a national level, or when it is not possible to configure the network to transport gas quickly enough from the points of supply to the points of demand. Any AOPs that are exceeded are categorised as an Exit constraint in our results.

Maximum Operating Pressures are the safe pressure limits at which we can operate our pipelines. Failure to keep our pipelines below these limits is caused by gas entering the network at a higher rate than it can be moved away for example using compression. Any MOPs that are exceeded are categorised as an Entry constraint in our results.

Compressors are designed to operate within certain parameters of flow and pressure; network configurations that require compressors to operate outside these parameters may indicate a need to modify or adapt the compressor to enable it to provide a different range of operation.

Gas system stock is the volume of gas stored within the NTS. We use this to maintain pressures, manage the flows throughout the network and the changes in supply and demand throughout the day. If demand exceeds supply, levels of gas stocks within the system will decrease as the gas system stock is used to meet the increase in demand requirements. This in turn will reduce system pressures which can impact our ability to meet AOPs across the network. Gaining a better understanding of what impact high gas-fired power generation demand swings will have on within-day gas system stock levels is critical.

Appendix 1
Analysis assumptions and methodology

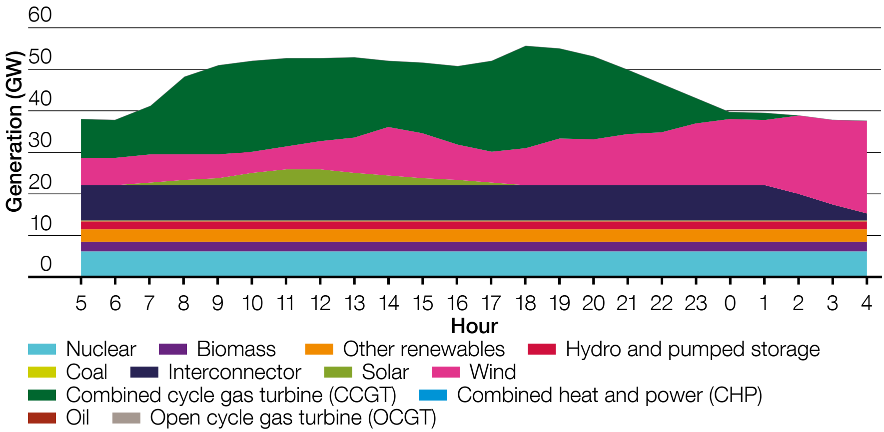
5.3
Analysis results

5.3.1
Power Market Model outputs

An output for a high CCGT swing day is shown in figure 5.2. This illustrates a number of features from our Power Market Model:

- The generation output of Solar and Wind reflect the weather features of the day being modelled; in this instance a winter's day with a relatively short period of solar generation, getting increasingly windy towards the end of the day.
- A number of generation types remain constant during the day, namely Nuclear, Biomass, Other Renewables and Coal.
- Gas CCGTs pick up the majority of the resulting flexibility requirement of the market.
- The high level of wind generation at the end of the gas day, when electricity demand is at its lowest, means that the requirement for CCGT generation falls to zero and the next provider of flexibility is electricity interconnection.
- Note that other sources of generation are included in the Power Market Model but are not selected to generate, being below CCGTs (and others) in the merit order, namely CHP, Oil and OCGT.

Figure 5.2
Power Market Model hourly electricity generation profiles (2023 Consumer Power – High CCGT swing day – CCGT and wind generation)



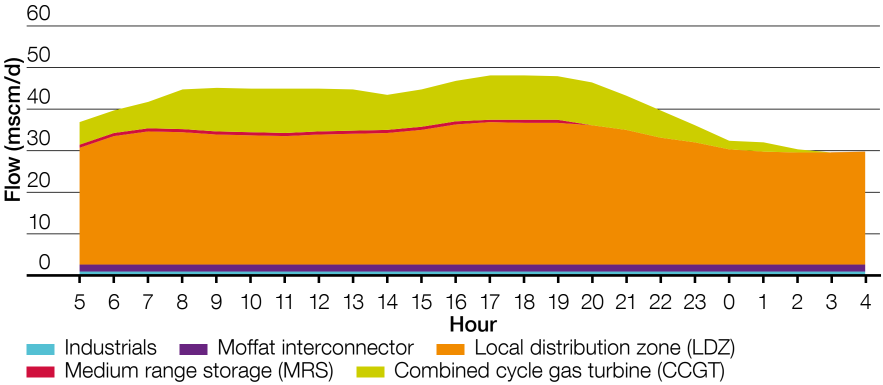
This last point is significant because it implies that a large proportion of CCGTs will generate when electricity demand is higher during the day; therefore CCGT profiling is likely to be highest when the wind increases at the end of the day which will cause most or all CCGTs to be turned down. This scenario is challenging for the NTS as it causes an increase in the volume of gas system stock depletion during the day. The challenge is exacerbated if supplies have the opposite profile and are at their highest at the end of the gas day when demand is lowest.

5.3.2
Gas Market Model outputs – demand

The hourly CCGT demand calculated by the Power Market Model is combined with other gas demands as illustrated in figure 5.3.

The pattern of CCGT demand in the scenario, shown in figure 5.3, results in a significant increase in the amount of gas system stock swing that the network has to accommodate. This is predominantly caused by the reduction in CCGT demand which occurs over the space of a few hours and coincides with the diurnal swing of LDZ demand.

Figure 5.3
Modelled hourly demand flows (2023 Consumer Power – High CCGT swing day)



Appendix 1
Analysis assumptions and methodology

5.3.3
Gas Market Model outputs – supply

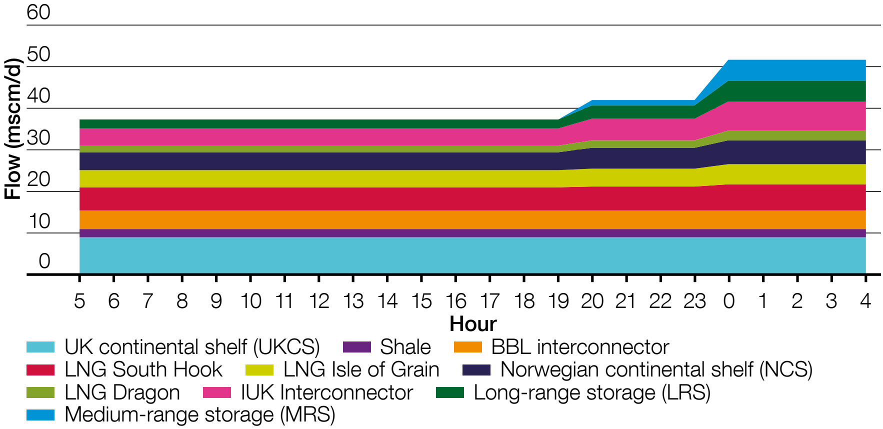
In order to create a gas supply model, historical analysis has been undertaken to determine the rate of response of different supply types to changes in demand. Figure 5.4 below illustrates the types of supply that have responded in this model output example:

- UKCS, shale and BBL are modelled as unresponsive (the latter is already running at maximum so does not have the capability to increase).
- Other supplies are shown in ascending order of responsiveness, with LNG response modelled separately by terminal.
- The most responsive supplies are IUK, long-range storage and medium-range storage.

The 'steps' in supply response have been assumed at 8pm and 12 midnight based on historical balancing actions taken by the GNCC.

There are many possible supply response combinations to deliver the required end-of-day balance. The assumptions made deliver a balanced pattern of response across a number of locations. Existing capacity obligations are such that the required increases could be delivered by fewer terminals, in which case entry constraints are more likely to be encountered.

Figure 5.4
Modelled hourly supply flows

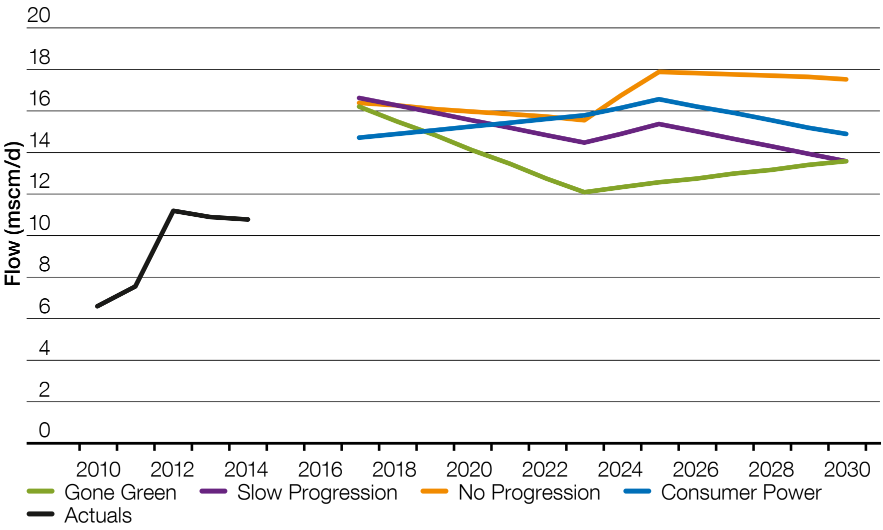


Chapter five

5.3.4
CCGT swing

The levels of CCGT demand swing derived from our modelling are substantially higher than the levels seen historically, across all four scenarios, as shown in figure 5.5 below. This is due to the increase in variability associated with a higher volume of CCGTs connecting to the NTS in the future and the application of assumptions which flex the FES (see Appendix 1). This typically occurs when there is a ramp up or down in CCGT demand to compensate for a change in renewable generation output, which coincides with the daily swing at the start or end of the day (as shown in figure 5.2).

Figure 5.5
Actual and modelled peak volume of CCGT swing



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The peak CCGT swings in the figure above are taken from single gas days in each scenario and therefore any trends from the data are not necessarily applicable to the datasets as a whole. Nonetheless, the data appears to show that the peak level of swing in the **Gone Green** scenario is the lowest of all the scenarios in the middle years (2023 and 2025); this is due to the relatively low volume of CCGT generation assumed in this scenario (see figure 5.1). Unlike the other scenarios, however, the peak level of swing in **Gone Green** does increase between 2025 and 2030, which is consistent with the higher level of renewables, particularly wind, in this scenario.

The peak level of CCGT swing is highest in the **No Progression** scenario, particularly towards the later years modelled. This is consistent with the **No Progression** scenario having the highest volume of CCGT generation and therefore having the highest capacity to provide swing, although it is likely that a greater proportion of this swing is being driven by the diurnal pattern of electricity generation as opposed to the intermittency of renewable generation, relative to the other scenarios.

5.3.5
2017 analysis results summary

Flat supply profile
In the 2017 scenarios analysed, it was possible to solve the network when a ‘flat supply’ profile was assumed.

High supply profile
When a ‘high supply swing’ supply profile was applied however, constraints were identified across all FES scenarios except **Slow Progression**. These constraints occurred as a result of a combination of within-day demand variation (including CCGTs) and late supply balancing in the South East (Bacton and Isle of Grain). Typically we found exit constraints in the South East as high demands and low supplies meant that AOPs could not be achieved; the converse problem was experienced late in the gas day as high supplies and low demands caused gas system stock levels to rise and MOPs to be exceeded.

Medium supply profile
The analysis then considered a ‘medium supply swing’ supply profile across all four scenarios, in which the networks could be solved without constraints.

We have not undertaken detailed analysis to identify the most appropriate mitigation for these constraints. In particular we have only considered the gas day with the highest CCGT swing and are not yet at the stage of understanding the potential frequency of these constraints. Given that it was possible to solve the network under the ‘flat’ and ‘medium supply swing’ supply profiles, and constraints were only identified in the ‘high supply swing’ supply profile, it is perhaps more likely that a combination of both asset and non-asset solutions will be the most appropriate:
Rules: changes to the balancing arrangements could be developed to encourage ‘flatter’ supply profiles.
Tools: existing energy balancing and/or constraint management tools such as locational actions could be utilised to support management of local gas system stock.
Assets: a combination of pipeline, compression and maintenance/non-build solutions could be considered to improve the resilience of the local area to variations in gas system stock.

5.3.6
2023 analysis results summary

Flat supply profile
In the 2023 scenarios analysed, it was possible to solve the network when a flat supply profile was assumed.

High supply profile
When a 'high supply swing' supply profile was applied, however, constraints were identified across all FES scenarios except **Gone Green**. These constraints occurred as a result of a combination of within-day demand variation (including CCGTs) and late supply balancing. In addition to the entry and exit constraints that were discussed in the 2017 results, a range of other constraints were identified:

- Failure to achieve AOPs in Scotland due to high demand and low supplies at St Fergus.
- Failure to achieve AOPs in the South West due to high demand and low supplies at Milford Haven in the early part of the gas day.

Medium supply profile
The analysis then considered a 'medium supply swing' supply profile across all four scenarios, in which the entry constraints were largely mitigated, but the exit constraints in Scotland and the South West could still not be resolved.

The issues with AOP breaches in Scotland are an ongoing issue for which we raised proposals and received funding as part of RIIO-T1. We continue to hold this issue under review pending a final decision on the most appropriate solution (unlikely to be implemented before RIIO-T2).

The AOP issues in the South West are largely confined to the **No Progression** scenario, which has the largest CCGT portfolio of the scenarios and as a consequence has a higher CCGT load in the South West. Although this analysis has been considered without any additional reinforcement for new power stations, it is possible that these additional power stations could trigger reinforcement in the South West which might alleviate some or all of the constraints identified.

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Appendix 1
Analysis assumptions and methodology

5.3.7
2030 analysis results summary

Flat supply profile
For the year 2030, constraints were identified in two scenarios when a flat supply profile was assumed:

- Failure to achieve AOPs in the South West, due to high CCGT demand profile in that area, in the **No Progression** scenario.
- MOP exceeded due to high supplies at Milford Haven, in the **Slow Progression** scenario.

As discussed in the 2023 results, it is possible that the additional CCGTs in the South West could trigger reinforcement which may alleviate these constraints. The Entry constraint at Milford Haven is not a direct consequence of CCGT profiling and reflects existing capacity risks in that area.

High supply profile
When a 'high supply swing' supply profile was applied, the above constraints were still present, with the addition of the failure to achieve AOPs in Scotland in the **Consumer Power** scenario, consistent with the findings from the 2023 analysis.

5.3.8
Regional sensitivities

In the GB electricity market many CCGTs have similar efficiencies, and many different market outcomes of similar economic consequence are possible even when quite different CCGTs are activated. This means that a wide range of spatial patterns of gas demand for power generation can be deemed equally likely to occur on a given day.

Thus, there is a potential for all CCGTs in a particular region to respond to the electricity market at the same time. Therefore, to assess the impact of that occurrence on the NTS, two regional sensitivities were carried out, one in the South East and the other in the South West.

For both these sensitivities, exit constraints were identified which meant that it was not possible to achieve AOPs in the South West in the **No Progression** and **Slow Progression** scenarios in 2023 and 2030. As discussed in the previous sections, it is possible that the additional CCGTs in the South West could trigger reinforcement which may alleviate these constraints.

Appendix 2
Glossary

Word	Acronym	Description
Advanced Reservation of Capacity Agreement	ARCA	This was an agreement between National Grid and a shipper relating to future NTS pipeline capacity for large sites in order that shippers can reserve NTS Exit Capacity in the long term. This has been replaced by the PARCA process. (See also PARCA)
Aggregate System Entry Point	ASEP	A System Entry point where there is more than one, or adjacent Connected Delivery Facilities; the term is often used to refer to gas supply terminals.
Annual power demand		The electrical power demand in any one fiscal year. Different definitions of annual demand are used for different purposes.
Annual Quantity	AQ	The AQ of a Supply Point is its annual consumption over a 365-day year.
Anticipated Normal Operating Pressure	ANOP	A pressure that we may make available at an offtake to a large consumer connected to the NTS under normal operating conditions. ANOPs are specified within the NExA agreement for the site.
Assured Offtake Pressure	AOP	A minimum pressure at an offtake from the NTS to a DN that is required to support the downstream network. AOPs are agreed and revised through the annual OCS process.
Average cold spell	ACS	Average cold spell: defined as a particular combination of weather elements which gives rise to a level of winter peak demand which has a 50% chance of being exceeded as a result of weather variation alone. There are different definitions of ACS peak demand for different purposes.
Balgzand–Bacton Line	BBL	A gas pipeline between Balgzand in the Netherlands and Bacton in the UK. **http://www.bblcompany.com**. This pipeline is currently uni-directional and flows from the Netherlands to the UK only.
Bar		The unit of pressure that is approximately equal to atmospheric pressure (0.987 standard atmospheres). Where bar is suffixed with the letter g, such as in barg or mbarg, the pressure being referred to is gauge pressure, i.e. relative to atmospheric pressure. One millibar (mbarg) equals 0.001 bar.
Baseload electricity price		The costs of electricity purchased to meet minimum demand at a constant rate.
BAT Reference Documents	BREF	BAT Reference Documents draw conclusions on what the BAT is for each sector to comply with the requirements of IED. The BAT conclusions drawn as a result of the BREF documents will then form the reference for setting permit conditions.
Best Available Technique	BAT	A term used in relation to Industrial Emissions Directive (IED) 2010. In this context BAT is defined as Best Available Technique and means applying the most effective methods of operation for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.
Billion cubic metres	bcm	Unit or measurement of volume, used in the gas industry. 1 bcm = 1,000,000,000 cubic metres.
Biomethane		Biomethane is a naturally occurring gas that is produced from organic material and has similar characteristics to natural gas. **http://www.biomethane.org.uk/**
Boil-off		A small amount of gas which continually boils off from LNG storage tanks. This helps to keep the tanks cold.
Calorific value	CV	The ratio of energy to volume measured in megajoules per cubic metre (MJ/m3), which for a gas is measured and expressed under standard conditions of temperature and pressure.
Capacity		Capacity holdings give NTS Users the right to bring gas onto or take gas off the NTS (up to levels of capacity held) on any day of the gas year. Capacity rights can be procured in the long term or through shorter-term processes, up to the gas day itself.

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Word	Acronym	Description
Capacity Market	CM	The Capacity Market is designed to ensure security of electricity supply. This is achieved by providing a payment for reliable sources of capacity, alongside their electricity revenues, ensuring they deliver energy when needed.
Carbon capture and storage	CCS	Carbon (CO_2) capture and storage (CCS) is a process by which the CO_2 produced in the combustion of fossil fuels is captured, transported to a storage location and isolated from the atmosphere. Capture of CO_2 can be applied to large emission sources like power plants used for electricity generation and industrial processes. The CO_2 is then compressed and transported for long-term storage in geological formations or for use in industrial processes.
Carbon dioxide	CO_2	Carbon dioxide (CO_2) is the main greenhouse gas and the vast majority of CO_2 emissions come from the burning of fossil fuels (coal, natural gas and oil).
Carbon dioxide equivalent	CO_2e	A term used relating to climate change that accounts for the “basket” of greenhouse gases and their relative effect on climate change compared to carbon dioxide. For example UK emissions are roughly 600m tonnes CO_2e. This constitutes roughly 450m tonnes CO_2 and less than the 150m tonnes remaining of more potent greenhouse gases such as methane, which has 21 times more effect as a greenhouse gas, hence its contribution to CO_2e will be 21 times its mass.
Combined Cycle Gas Turbine	CCGT	Gas turbine that uses the combustion of natural gas or diesel to drive a gas turbine generator to generate electricity. The residual heat from this process is used to produce steam in a heat recovery boiler which in turn, drives a steam turbine generator to generate more electricity. (See also OCGT)
Combined Heat and Power	CHP	A system whereby both heat and electricity are generated simultaneously as part of one process. Covers a range of technologies that achieve this.
Comité Europeén de Normalisation	CEN	European committee for standardisation concerned with the development, maintenance and distribution of standards and specifications.
Composite Weather Variable	CWV	A measure of weather incorporating the effects of both temperature and wind speed. We have adopted the new industry wide CWV equations that took effect on 1 October 2015.
Compressed natural gas	CNG	Compressed natural gas is made by compressing natural gas to less than 1 per cent of the volume it occupies at standard atmospheric pressure.
Compressor station		An installation that uses gas turbine or electricity-driven compressors to boost pressures in the pipeline system. Used to increase transmission capacity and move gas through the network.
Connected System Exit Point	CSEP	A point at which natural gas is supplied from the NTS to a connected system containing more than one supply point. For example a connection to a pipeline system operated by another Gas Transporter.
Constrained LNG	CLNG	A service available at some LNG storage facilities whereby Shippers agree to hold a minimum inventory in the facility and flow under certain demand conditions at National Grid’s request. In exchange Shippers receive a transportation credit from National Grid.
Consumer Power Scenario	CP	A National Grid scenario defined in the *Future Energy Scenarios (FES)* document whereby the focus is on a market-driven world, with limited government intervention. High levels of prosperity allow for high investment and innovation. New technologies are prevalent and focus on the desires of consumers over and above reducing greenhouse gas emissions.
Contract for Difference	CfD	Contract between the Low Carbon Contracts Company (LCCC) and a low carbon electricity generator designed to reduce its exposure to volatile wholesale prices.
Cubic metre	m^3	The unit of volume, expressed under standard conditions of temperature and pressure, approximately equal to 35.37 cubic feet. One million cubic metres (mcm) are equal to 106 cubic metres, one billion cubic metres (bcm) equals 109 cubic metres.

Word	Acronym	Description
Daily Flow Notification	DFN	A communication between a Delivery Facility Operator (DFO) and National Grid, indicating hourly and end-of-day entry flows from that facility.
Daily Metered Supply Point	DM	A Supply Point fitted with equipment, for example a datalogger, which enables meter readings to be taken on a daily basis.
Delivery Facility Operator	DFO	The operator of a reception terminal or storage facility, who processes and meters gas deliveries from offshore pipelines or storage facilities before transferring the gas to the NTS.
Department of Business, Energy & Industrial Strategy	BEIS	This is a newly formed UK government department that replaces DECC.
Department of Energy & Climate Change	DECC	Formerly a UK government department: the Department of Energy & Climate Change (DECC) became part of the Department for Business, Energy & Industrial Strategy (BEIS) in July 2016.
Development Consent Order	DCO	A statutory Order under the Planning Act (2008) which provides consent for a development project. Significant new pipelines require a DCO to be obtained, and the construction of new compressor stations may also require DCOs if a new high voltage (HV) electricity connection is required.
Directly Connected (offtake)	DC	Direct connection to the NTS typically to power stations and large industrial users, i.e. the connection is not via supply provided from a Distribution Network.
Distribution Network	DN	A gas transportation system that delivers gas to industrial, commercial and domestic consumers within a defined geographical boundary. There are currently eight DNs, each consisting of one or more Local Distribution Zones (LDZs). DNs typically operate at lower pressures than the NTS.
Distribution Network Operator	DNO	Distribution Network Operators own and operate the Distribution Networks that are supplied by the NTS.
Distribution system		A network of mains operating at three pressure tiers: intermediate (2 to 7 barg), medium (75 mbarg to 2 barg) and low (less than 75 mbarg).
Diurnal storage		Gas stored for the purpose of meeting, among other things, within-day variations in demand. Gas can be stored in special installations, such as in the form of gas system stock within transmission, i.e. >7 barg, pipeline systems.
Electricity Market Reform	EMR	A government policy to incentivise investment in secure, low-carbon electricity, improve the security of Great Britain's electricity supply, and improve affordability for consumers. The Energy Act 2013 introduced a number of mechanisms. In particular: ■ a Capacity Market, which will help ensure security of electricity supply at the least cost to the consumer ■ contracts for Difference, which will provide long-term revenue stabilisation for new low carbon initiatives. Both will be administered by delivery partners of the Department of Business, Energy and Industrial Strategy (BEIS). This includes National Grid Electricity Transmission (NGET).
Electricity Ten Year Statement	*ETYS*	The *ETYS* illustrates the potential future development of the National Electricity Transmission System (NETS) over a ten-year (minimum) period and is published on an annual basis.

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Word	Acronym	Description
Emission Limit Value	ELV	Pollution from larger industrial installations is regulated under the Pollution Prevention and Control regime. This implements the EU Directive on Integrated Pollution Prevention and Control (IPPC) (2008/1/EC). Each installation subject to IPPC is required to have a permit containing emission limit values and other conditions based on the application of Best Available Techniques (BAT) and set to minimise emissions of pollutants likely to be emitted in significant quantities to air, water or land. Permit conditions also have to address energy efficiency, waste minimisation, prevention of accidental emissions and site restoration.
Energy Networks Association	ENA	The Energy Networks Association is an industry association funded by gas or transmission and distribution licence holders.
Environmental Impact Assessment	EIA	Environmental study of proposed development works as required under EU regulation and the Town and Country Planning (Environmental Impact Assessment) Regulations 2011. These regulations apply the EU directive "on the assessment of the effects of certain public and private projects on the environment" (usually referred to as the Environmental Impact Assessment Directive) to the planning system in England.
European Network of Transmission System Operators for Gas	ENTSOG	Organisation to facilitate cooperation between national gas Transmission System Operators (TSOs) across Europe to ensure the development of a pan-European transmission system in line with European Union energy goals.
Exit Zone		A geographical area (within an LDZ) that consists of a group of supply points that, on a peak day, receive gas from the same NTS offtake.
Front End Engineering Design	FEED	The FEED is basic engineering which comes after the Conceptual design or Feasibility study. The FEED design focuses on the technical requirements as well as an approximate budget investment cost for the project.
Future Energy Scenarios	FES	The FES is a range of credible futures which has been developed in conjunction with the energy industry. They are a set of scenarios covering the period from now to 2050, and are used to frame discussions and perform stress tests. They form the starting point for all transmission network and investment planning, and are used to identify future operability challenges and potential solutions.
Gas Deficit Warning		The purpose of a Gas Deficit Warning is to alert the industry to a requirement to provide a within-day market response to a physical supply / demand imbalance.
Gas Safety (Management) Regulations 1996	GS(M)R	Regulations which apply to the conveyance of natural gas (methane) through pipes to domestic and other consumers and cover four main areas: (a) the safe management of gas flow through a network, particularly those parts supplying domestic consumers, and a duty to minimise the risk of a gas supply emergency (b) arrangements for dealing with supply emergencies (c) arrangements for dealing with reported gas escapes and gas incidents (d) gas composition. Gas Transporters are required to submit a safety case to the HSE detailing the arrangements in place to ensure compliance with GS(M)R requirements.
Gas Supply Year		A twelve-month period commencing 1 October, also referred to as a Gas Year.
Gas System Stock Level or Linepack		The volume of gas within the National or Local Transmission System at any time.
Gas Ten Year Statement	*GTYS*	The *Gas Ten Year Statement* is published annually in accordance with National Grid Gas plc's obligations in Special Condition 7A of the Gas Transporters Licence relating to the National Transmission System and to comply with Uniform Network Code (UNC) requirements.

Word	Acronym	Description
Gas Transporter		Formerly Public Gas Transporter (PGT), GTs, such as National Grid, are licensed by the Gas and Electricity Markets Authority (GEMA) to transport gas to consumers.
Gasholder		A vessel used to store gas for the purposes of providing diurnal storage.
Gigawatt	GW	1,000,000,000 watts, a measure of power.
Gigawatt hour	GWh	1,000,000,000 watt hours, a unit of energy.
Gone Green scenario	GG	A National Grid scenario defined in the *Future Energy Scenarios (FES)* document whereby the focus is on long-term environmental goals, high levels of prosperity and advanced European harmonisation that ensure that the 2050 carbon reduction target is achieved.
Gram of carbon dioxide per kilowatt hour	gCO_2/kWh	Measurement of CO_2 equivalent emissions per kWh of energy used or produced.
Great Britain	GB	A geographical, social and economic grouping of countries that contains England, Scotland and Wales.
Industrial Emissions Directive	IED	The Industrial Emissions Directive came into force on 6 January 2011. IED recasts seven existing Directives related to industrial emissions into a single clear, coherent legislative instrument. The recast includes IPPC, LCP, the Waste Incineration Directive, the Solvents Emissions Directive and three Directives on Titanium Dioxide.
Integrated Gas Management Control System	IGMS	Used by National Grid System Operation to control and monitor the Gas Transmission system, and also to provide market information to interested stakeholders within the gas industry.
Integrated Pollution Prevention & Control Directive 1999	IPPC	Emissions from our installations are subject to EU-wide legislation; the predominant legislation is the Integrated Pollution Prevention & Control (IPPC) Directive 1999, the Large Combustion Plant Directive (LCPD) 2001 and the Industrial Emissions Directive (IED) 2010. The requirements of these directives have now been incorporated into the Environmental Permitting (England and Wales) (Amendment) Regulations 2013 (with similar regulations applying in Scotland). IPPC aims to reduce emissions from industrial installations and contributes to meeting various environment policy targets and compliance with EU directives. Since 31 October 2000, new installations are required to apply for an IPPC permit. Existing installations were required to apply for an IPPC permit over a phased timetable until October 2007.
Interconnector		A pipeline transporting gas to another country. The Irish Interconnector transports gas across the Irish Sea to both the Republic of Ireland and Northern Ireland. The Belgian Interconnector (IUK) transports gas between Bacton and Zeebrugge. The Belgian Interconnector is capable of flowing gas in either direction. The Dutch Interconnector (BBL) transports gas between Balgzand in the Netherlands and Bacton. It is currently capable of flowing only from the Netherlands to the UK.
Interconnector (UK)	IUK	A bi-directional gas pipeline between Bacton in the UK and Zeebrugge Belgium. **http://www.interconnector.com**
International Energy Agency	IEA	An intergovernmental organisation that acts as energy policy advisor to 28 member countries.
Kilowatt Hour	kWh	A unit of energy used by the gas industry. Approximately equal to 0.0341 therms. One megawatt hour (MWh) equals 1000 kWh, one gigawatt hour (GWh) equals 1000 MWh, and one terawatt hour (TWh) equals 1000 GWh.
Large Combustion Plant Directive 2001	LCP	The Large Combustion Plant Directive is a European Union Directive which introduced measures to control the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plant, including power stations.

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Word	Acronym	Description
Linepack or Gas System Stock Level		The volume of gas within the National or Local Transmission System at any time.
Liquefied natural gas	LNG	LNG is formed by chilling gas to -161°C so that it occupies 600 times less space than in its gaseous form. **www2.nationalgrid.com/uk/Services/Grain-lng/what-is-lng/**
Liquefied Natural Gas Storage	LNGS	The storage of liquefied natural gas.
Load duration curve (1-in-50 severe)		The 1-in-50 severe load duration curve is that curve which, in a long series of years, with connected load held at the levels appropriate to the year in question, would be such that the volume of demand above any given demand threshold (represented by the area under the curve and above the threshold) would be exceeded in one out of fifty years.
Load duration curve (average)		The average load duration curve is that curve which, in a long series of winters, with connected load held at the levels appropriate to the year in question, the average volume of demand above any given threshold, is represented by the area under the curve and above the threshold.
Local Distribution Zone	LDZ	A gas distribution zone connecting end users to the (gas) National Transmission System.
Local Transmission System	LTS	A pipeline system operating at >7 barg that transports gas from NTS / LDZ offtakes to distribution system low pressure pipelines. Some large users may take their gas direct from the LTS.
Long range storage or seasonal storage	LRS	There is one long-range storage site on the national transmission system: Rough, situated off the Yorkshire coast. Rough is owned by Centrica and mainly puts gas into storage (called 'injection') in the summer and takes gas out of storage in the winter. **http://www2.nationalgrid.com/UK/Our-company/Gas/Gas-Storage/**
Long Term System Entry Capacity	LTSEC	NTS Entry Capacity available on a long-term basis (up to 17 years into the future) via an auction process. This is also known as Quarterly System Entry Capacity (QSEC).
Margins Notice		The purpose of the Margins Notice is to provide the industry with a day ahead signal that there may be the need for a market response to a potential physical supply / demand imbalance.
Maximum Operating Pressure	MOP	These are safe pressure limits at which we can operate our pipelines.
Medium Combustion Plant (Directive)	MCP	The Medium Combustion Plant (MCP) directive will apply limits on emissions to air from sites below 50 MW thermal input. MCP is likely to come into force by 2020.
Medium-range storage	MRS	Typically, these storage facilities have very fast injection and withdrawal rates that lend themselves to fast day-to-day turn rounds as market prices and demand dictate.
Megawatt hour	MWh	1,000,000 watts, a measure of power usage or consumption in 1 hour.
Million cubic metres	mcm	Unit or measurement of volume, used in the gas industry. 1 mcm = 1,000,000 cubic metres.
National balancing point	NBP	The wholesale gas market in Britain has one price for gas irrespective of where the gas comes from. This is called the national balancing point (NBP) price of gas and is usually quoted in price per therm of gas.
National Transmission System	NTS	A high-pressure gas transportation system consisting of compressor stations, pipelines, multijunction sites and offtakes. NTS pipelines transport gas from terminals to NTS offtakes and are designed to operate up to pressures of 94 bar(g).

Word	Acronym	Description
National Transmission System Offtake		An installation defining the boundary between NTS and LTS or a very large consumer. The offtake installation includes equipment for metering, pressure regulation, odourisation equipment etc.
Network Development Process	NDP	NDP defines the method for decision making, optioneering, development, sanction, delivery and closure for all National Grid gas projects. The aim of the NDP is to deliver projects that have the lowest whole-life cost, are fit for purpose and meet stakeholder and RIIO requirements.
Network Exit Agreement	NExA	A NExA is signed by a gas shipper or Distribution Network Operator prior to any gas being taken off the system. Within the NExA the gas transporter sets out the technical and operational conditions of the offtake such as the maximum permitted flow rate, the assured offtake pressure and ongoing charges.
Network Gas Supply Emergency	NGSE	A NGSE occurs when National Grid is unable to maintain a supply – demand balance on the NTS using its normal system balancing tools. A NGSE could be caused by a major loss of supplies to the system as a result of the failure of a gas terminal or as the result of damage to a NTS pipeline affecting the ability of the system to transport gas to consumers. In such an event the Network Emergency Co-ordinator (NEC) would be requested to declare a NGSE. This would enable National Grid to use additional balancing tools to restore a supply – demand balance. Options include requesting additional gas supplies be delivered to the NTS or requiring gas consumers, starting with the largest industrial consumers, to stop using gas. These tools will be used, under the authorisation of the NEC, to try to maintain supplies as long as possible to domestic gas consumers.
Network Options Assessment	*NOA*	The *NOA* builds upon the future capacity requirements in our *Electricity Ten Year Statement (ETYS)* and presents the network investment recommendations that we believe will meet these requirements across the GB electricity transmission network.
Nitrous oxide	NOx	A group of chemical compounds, some of which are contributors to pollution, acid rain or are classified as greenhouse gases.
No Progression scenario	NP	Compared to Gone Green there is less money available and less emphasis on sustainability. There is slower economic recovery and Government policy and regulation remains the same as today, and no new targets are introduced. The 2020 renewable energy target for 2020 is unlikely to be met.
Non-Daily Metered	NDM	A meter that is read monthly or at longer intervals. For the purposes of daily balancing, the consumption is apportioned, using an agreed formula, and for supply points consuming more than 73.2 MWh pa, reconciled individually when the meter is read.
Odourisation		The process by which the distinctive odour is added to gas supplies to make it easier to detect leaks.
Office of Gas and Electricity Markets	Ofgem	The UK's independent National Regulatory Authority, a non-ministerial government department. Their principal objective is to protect the interests of existing and future electricity and gas consumers.
Offtake Capacity Statement	OCS	This is the process by which Distribution Network Operators apply for Exit (Flex) Capacity on an annual basis. This allows the DNOs to request changes to the Exit (Flex) Capacity holdings and also request increases in assured offtake pressures.
Oil & Gas UK		Oil & Gas UK is a representative body for the UK offshore oil and gas industry. It is a not-for-profit organisation, established in April 2007. **http://www.oilandgasuk.co.uk**
On-the-day Commodity Market	OCM	This market constitutes the balancing market for GB and enables anonymous financially cleared on-the-day trading between market participants.
Open Cycle Gas Turbine	OCGT	Gas turbines in which air is first compressed in the compressor element before fuel is injected and burned in the combustor. (See also CCGT)
Operating margins	OM	Gas used by National Grid Transmission to maintain system pressures under certain circumstances, including periods immediately after a supply loss or demand forecast change, before other measures become effective and in the event of plant failure, such as pipe breaks and compressor trips.

Appendix 2
Glossary

Word	Acronym	Description
Own Use Gas		Gas used by National Grid to operate the transportation system. Includes gas used for compressor fuel, heating and venting.
Peak day demand, Electricity		The maximum power demand in any one fiscal year: Peak demand typically occurs at around 17:30hrs on a week-day between December and February. Different definitions of peak demand are used for different purposes.
Peak day demand, Gas		The 1-in-20 peak day demand is the level of demand that, in a long series of winters, with connected load held at levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once.
Per annum	pa	Per year
Planning and Advanced Reservation of Capacity Agreement	PARCA	A solution developed in line with the enduring incremental capacity release solutions which have been developed following the implementation of the Planning Act (2008). PARCAs were implemented on 1 February 2015 and replace the functions of PCAs and ARCAs. (See also ARCA & PCA)
Planning Consent Agreement	PCA	Planning Consent Agreements were made in relation to NTS Entry and Exit Capacity requests and comprised a bilateral agreement between National Grid and developers, DNOs or Shippers whereby National Grid assessed the Need Case for NTS reinforcement and would undertake any necessary planning activities ahead of a formal capacity signal from the customer. Where a Need Case was identified, the customer would underwrite National Grid NTS to undertake the required statutory Planning Act activities such as strategic optioneering, Environmental Impact Assessment, statutory and local community consultations, preparation of the Development Consent Order (DCO) and application. This has now been replaced by the PARCA process. (See PARCA)
Power Market model		This model is used to provide outputs that simulate credible power market conditions based on a variety of factors such as energy prices, generation type and availability, supply and demand etc.
Project customer low cost connections	CLoCC	National Grid secured £4.8m of Ofgem funding to design and build an innovative solution to reduce the time and cost of connecting to the NTS for new and existing customers. For more information on the project visit the website: **http://projectclocc.com**
Projected Closing Linepack	PCLP	Linepack is the volume of gas stored within the NTS. Throughout a gas day linepack levels fluctuate due to imbalances between supply and demand over the day. National Grid, as residual balancer of the UK gas market, need to ensure an end-of-day market balance where total supply equals, or is close to, total demand. The Projected Closing Linepack (PCLP) metric is used as an indicator of end-of-day market balance. (See also Linepack or Gas System Stocks)
Quarterly System Entry Capacity	QSEC	NTS entry capacity available on a long-term basis (up to 17 years into the future) via an auction process. Also known as Long Term System Entry Capacity (LTSEC).
RIIO-T1		RIIO relates to the current Ofgem price control period which runs from 1 April 2013 to 31 March 2021. For National Grid Transmission this is referred to as RIIO-T1.
Safety Monitors		Safety Monitors in terms of space and deliverability are minimum storage requirements determined to be necessary to protect loads that cannot be isolated from the network and also to support the process of isolating large loads from the network. The resultant storage stocks or monitors are designed to ensure that sufficient gas is held in storage to underpin the safe operation of the gas transportation system under severe conditions. There is now just a single safety monitor for space and one for deliverability. These are determined by National Grid to meet its Uniform Network Code requirements and the terms of its safety case. Total shipper gas stocks should not fall below the relevant monitor level (which declines as the winter progresses). National Grid is required to take action (which may include use of emergency procedures) in order to prevent storage stocks reducing below this level.

Word	Acronym	Description
Scottish Environment Protection Agency	SEPA	The environmental regulator for Scotland.
Seasonal Normal Composite Weather Variable	SNCWV	The seasonal normal value of the CWV is the smoothed average of the values of the applicable CWV for that day in a significant number of previous years. (See also CWV)
Shale gas		Shale gas is natural gas that is found is shale rock. It is extracted by injecting water, sand and chemicals into the shale rock to create cracks or fractures so that the shale gas can be extracted. **https://www.gov.uk/government/publications/about-shale-gas-and-hydraulic-fracturing-fracking**
Shearwater Elgin Area Line	SEAL	The offshore pipeline from the Central North Sea (CNS) to Bacton.
Shipper or Uniform Network Code (Shipper) User		A company with a Shipper Licence that is able to buy gas from a producer, sell it to a supplier and employ a GT to transport gas to consumers.
Shrinkage		Gas that is input to the system but is not delivered to consumers or injected into storage. It is either Own Use Gas or Unaccounted for Gas.
Slow Progression scenario	SP	A National Grid scenario defined in the *Future Energy Scenarios (FES)* document whereby the 2020 renewable energy target for 2020 is not met. Although regulation and targets are similar to the Gone Green scenario there is less economic growth which prevents delivery of environmental policy and targets.
Strategic Options Report	SOR	Output of the PCA, ARCA and PARCA statutory Planning Act activities reporting to the customer on the findings of optioneering analysis by National Grid in relation to the customer request for NTS Entry or Exit Capacity.
Substitution		Capacity substitution is the process of moving unsold capacity from one or more system points to another, where demand for that capacity exceeds the available capacity quantities for the relevant period. This avoids the construction of new assets or material increases in operational risk.
Supplier		A company with a supplier's licence contracts with a shipper to buy gas, which is then sold to consumers. A supplier may also be licensed as a shipper.
Supply Hourly Quantity	SHQ	The quantity of supply on an hourly basis.
Supply Offtake Quantity	SOQ	The maximum daily consumption at a Supply Point.
Supply Point		A group of one or more meter points at a site.
System Operability		The ability to maintain system stability and all of the asset ratings and operational parameters within pre-defined limits safely, economically and sustainably.
System Operator	SO	An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure. Unlike a TSO, the SO may not necessarily own the assets concerned. For example, National Grid operates the electricity transmission system in Scotland, which is owned by Scottish Hydro Electricity Transmission and Scottish Power.
Terawatt hour	TWh	1,000,000,000,000 watt hours, a unit of energy.
Therm		An imperial unit of energy. Largely replaced by the metric equivalent: the kilowatt hour (kWh). 1 therm equals 29.3071 kWh.

Appendix 2
Glossary

Word	Acronym	Description
Transmission Entry Capacity	TEC	The maximum amount of active power deliverable by a power station at its grid entry point (which can be either onshore or offshore). This will be the maximum power deliverable by all of the generating units within the power station, minus any auxiliary loads.
Transmission Planning Code	TPC	The Transmission Planning Code describes National Grid's approach to planning and developing the NTS in accordance with its duties as a gas transporter and other statutory obligations relating to safety and environmental matters. The document is subject to approval by the Gas and Electricity Markets Authority (GEMA).
Transmission System Operator	TSO	An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure.
Unaccounted for Gas	UAG	Gas "lost" during transportation. Includes leakage, theft and losses due to the method of calculating the Calorific Value.
Uniform Network Code	UNC	The Uniform Network Code is the legal and commercial framework that governs the arrangements between the Gas Transporters and Shippers operating in the UK gas market. The UNC comprises different documents including the Transportation Principal Document (TPD) and Offtake Arrangements Document (OAD).
United Kingdom Continental Shelf	UKCS	The UK Continental Shelf (UKCS) comprises those areas of the sea bed and subsoil beyond the territorial sea over which the UK exercises sovereign rights of exploration and exploitation of natural resources.
United Kingdom of Great Britain and Northern Ireland	UK	A geographical, social and economic grouping of countries that contains England, Scotland, Wales and Northern Ireland.
Variable Speed Drives	VSD	Compressor technology where the drive speed can be varied with changes in capacity requirement. Variable speed drive compressors compared to constant speed compressors are more energy efficient and operate more quietly by varying speed to match the workload.
Weather-corrected demand		The actual demand figure that has been adjusted to take account of the difference between the actual weather and the seasonal normal weather.

Continuing the conversation

Get involved in the debate on the future of energy and join our LinkedIn group
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